

**EFFECT OF WEATHER PARAMETERS ON LINSEED (*Linum
usitatissimum* L.) VARIETIES UNDER EXTENDED SOWING
TIMES**

A Thesis submitted to the

MAHATMA PHULE KRISHI VIDYAPEETH,
RAHURI - 413 722, DIST.AHMEDNAGAR,
MAHARASHTRA (INDIA)

By

Mr. YADAV EKNATHRAO KADAM
(Reg. No.12/309)

in partial fulfilment of the requirements for the degree of
MASTER OF SCIENCE (AGRICULTURE)

In

AGRICULTURAL METEOROLOGY

**DEPARTMENT OF AGRICULTURAL METEOROLOGY
CENTRE OF ADVANCED FACULTY TRAINING (CAFT) IN
AGRICULTURAL METEOROLOGY
COLLEGE OF AGRICULTURE, PUNE – 411 005
MAHARASHTRA STATE (INDIA)**

(2014)

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I hereby declare that this thesis entitled “ **Effect of weather parameters on linseed (*Linum usitatissimum* L.) varieties under extended sowing times**” or part of there has not been submitted by me or any other person to any university or institute for Degree or Diploma.

Place : Pune-5
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Finally, I am deeply obliged to all the authors past and present whose literature has been cited.

Place : Pune

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Date : / /2014.

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LIST OF ABBREVIATIONS

$^{\circ}\text{C}$	: Degree Celsius
C.D.	: Critical difference
cm	: Centimeter(s)
DAS	: Days after sowing
dm^2	: Square decimeter (s)
<i>et al.</i>	: et alli i.e. and other
EC	: Electrical conductivity
etc.	: Et cetra
Fig.	: Figure
g	: Gram(s)
GDD	: Growing degree days
Ha	: Hectare
Hr	: Hour
i.e.	: Id est (that is)
K	: Potassium
Kg	: Kilogram(s)
kg ha^{-1}	: Kilogram hectare ⁻¹
max.	: Maximum
min.	: Minimum
MJ	: Mega Joule
mm	: Millimetres
N.S.	: Non-significant
No.	: Number
P	: Phosphorus
PAR	: Photosynthetically active radiation
RH	: Relative Humidity
q ha^{-1}	: Quintal hectare ⁻¹
SE	: Standard error
Sr.	: Serial
<i>viz.</i> ,	: Videlicet (namely)
%	: Per cent
/	: Per
@	: At the rate of
$\mu \text{ mol m}^{-2}\text{s}^{-1}$	: Micro mol meter ⁻¹ square second ⁻¹

ABSTRACT

EFFECT OF WEATHER PARAMETERS ON LINSEED (*Linum usitatissimum* L.) VARIETIES UNDER EXTENDED SOWING TIMES

By

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A candidate for the degree
Of
MASTER OF SCIENCE (AGRICULTURE)
In
AGRICULTURAL METEOROLOGY
2014

Research Guide	:	Prof. A.A. Shaikh
Department	:	Agricultural Meteorology

An experiment entitled, “effect of weather parameters on linseed (*Linum usitatissimum* L.) varieties under extended sowing times” was carried out during *rabi*, 2013-14 at Agricultural Meteorology Department Farm, (CAFT), College of Agriculture, Pune-5.

The field experiment was laid out in a split plot design with three replications. There were forty five treatment combinations comprising of three varieties *viz.*, PKVNL-260, NL-97, and Padmini as main plot treatments and five sowing times *viz.*, 44th, 45th, 46th, 47th and 48th MW as sub plot treatments. The gross and net plot sizes were 3.00 m x 2.4 m and 2.20 m x 1.80 m, respectively. A spacing of 30 cm x 5 cm was adopted by using 3 kg seed ha⁻¹. A recommended dose of fertilizer

Abstract contd....

Shri. Y. E. KADAM

(50:25:00 kg N, P, K ha⁻¹) was applied uniformly to all the treatments.

The periodical observations on growth, micrometeorological parameters and yield contributing characters were recorded to assess the treatment effects.

Among the three different varieties of linseed, PKVNL-260 recorded significantly higher growth parameters viz., plant height, plant spread, number of branches per plant, days to 50% flowering, days to maturity and dry matter per plant with yield attributing characters viz., number of capsules per plant, weight of seed per plant (g) and thousand seed weight i.e. test weight (g). The variety PKVNL-260 was significantly superior over other varieties.

The highest grain, straw yields and biological yield were recorded with the variety PKVNL-260 due to increased seed yield (kg ha⁻¹) than other varieties.

Sowing of *rabi* linseed during 45th MW favourably influenced all the growth components viz., plant height, plant spread, number of branches plant⁻¹, days to 50% flowering, day to maturity and dry matter per plant (g) with yield component viz., number of capsules plant⁻¹, no. of seeds per capsule, weight of dry capsules per plant (g), weight of seed per plant (g) and thousand seed weight i.e. test weight (g).

The highest grain, straw yields and biological yields were recorded when linseed sown during 45th MW.

When PKVNL-260 variety of linseed was sown during 45th MW produced significant interaction effect on plant height, plant spread, No. of branches per plant, dry matter per plant, 50% of flowering, no. of seeds/capsule, days to maturity, weight of capsules per plant and no. of capsules per plant at all the growth stages.

Based upon the above findings, it could be concluded that remunerative cultivation of *rabi* linseed variety PKVNL-260 sown during 45th MW was beneficial for achieving higher production.

Shri. Y. E. Kadam**Pages 1 to 114**

1.INTRODUCTION

Linseed (*Linum usitatissimum L*) is an important *rabi* oilseed crop of India belongs to the family linaceae. It is sixth largest oilseed crop in the world and is one of the oldest cultivated plants. It is an industrial crop cultivated for seeds, fiber and oil. All plant parts have extensive and varied uses. It is annual plant which attains the height of 80-100 cm depending upon the type of cultivar. It is grown under rainfed (63%), utera (20%) and irrigated (17%) conditions. It contains 35 to 47 per cent oil and 11 to 32% protein. The oil extracted from linseed is mainly used in paint industries as a medium for oil paint, pad ink and printing ink etc. The oil is also used to some extent in the soap industries, pharmaceutical industries and other allied industries. In India, the paint and allied industries are the major consumer of linseed accounting to 70 per cent of the total consumption. Linseed oil is also used in adulteration of the mustard oil, whenever the price of the latter is high. The major states that consume linseed oil in India are West Bengal, Maharashtra, Delhi and Uttar Pradesh accounting for 25 per cent of the total consumption in India. (Anonymous,2003).

Flax seed oil is comprised of 5 major fatty acids namely palmitic acid, stearic acid, oleic acid, linoleic acid and linolenic acid. Alfa linolenic acid provides beneficial effects on numerous clinical conditions such as cardiovascular diseases, inflammatory disorders, cancer and immune functions etc. Amongst the saturated fatty acids, palmitic acid is found very significantly from 4.08-8.69 %,whereas, stearic acid varies from 2.02-7.75 %. Amongst the unsaturated fatty acids, oleic acid varies from 18.44-37.32 %. Linoleic and linolenic acids are essential fatty acids and both varied widely from 9.45-20.27 % and 33.22-63.43 %, respectively (Kamlesh, *et al.*,2002).

The oil cake is considered to be a good in taste and contains 36 per cent protein, out of which 85 per cent is digestible. It is a valuable cattle feed, especially for milch animals. It contains 5.5 to 5.6 percent nitrogen, 1.4 to 1.5 per cent phosphorus and 1.2 to 1.3 per cent potassium. It is also used as good organic manure. Linseed straw is used for manufacture of fibre of good quality having strength and durability. Fibers are lustrous and can be blend well with wool, silk cotton etc. Linseed straw is used in manufacturing papers and plastics.

The fibre is used for the manufacturing of linen goods such as strong twine, canvas, suiting and shirtings, water resistant pipes and various indispensable products regularly used by defence service people. The wooly matter and short fibre may be used as a raw pulp for making paper of high quality. Due to these distinct features of dual purpose of linseed, its demand is increasing these days.

In the world, linseed is grown on an area of 3.06 million ha with a production of 2.2 million tonnes and productivity of 720 kg ha⁻¹. Presently the area under linseed in India is 5.0 lakh ha with a production of 1.30 lakh tonnes and the productivity is 349 kg per ha which is less than world's productivity (720 kg ha⁻¹). In Maharashtra linseed occupies an area of 30.30 thousand ha with a production of 12.30 thousand tonnes and productivity 406 kg per ha. (Anonymous, 2012).

1.1. Soil and climate requirement of Linseed:

Linseed can grow on all types of soil, where sufficient moisture is available. However, it does better in clayey soil having more water retention capacity when grown under stored soil moisture. It grows best on well-drained loam to clay loam soils having higher clay and lime content. It is also grown on the light alluvial soil of UP, Bihar and West Bengal. The temperature is an important meteorological variable that affect plant growth and development particularly in *rabi* season. The

linseed crop does well under moderate cold but the fibre crop grow best in cool moist climate. It requires dry weather condition during maturity. Linseed crop require moderate or cool temperature during the vegetative development stage. This crop thrives well in the temperature range of 25 °C to 30 °C during germination and about 15 °C to 20 °C during seed formation i.e. reproductive growth stage.

It is reported that high temperature above 32⁰C accompanied with drought during flowering reduced yield, oil content and the quality of crop. Linseed crop may be damaged or destroyed at a temperature between –8 °C and 3 °C at seedling stage. However, during other stages plant may survive at a temperature of –9 °C or even lower (Rajendra Prasad, 2004).

Linseed is fairly resistant to drought and grows well in areas receiving annual rainfall of 450-750 mm. The crop can thrive well under rain free condition. However, well-distributed small amount of rainfall during growing period was found to be ideal. It is also grown in dry climate with timely irrigation (Rajendra Prasad, 2004).

1.2. Date of sowing:

The area under cultivation of linseed is increasing recently but work on the agro meteorological aspect is limited. Consequently, it is difficult to recommend weather based better agronomic practices for higher yield. Yield variation in a crop is mainly affected by biotic and abiotic factors. Amongst these factors date of sowing is an important factor contributing to higher yield. The seed yield is influenced considerably by different dates of sowing suggested by various workers. Delayed sowing after 15th October reduced the seed as well as straw yield. Yield attributes viz, number of capsules plant⁻¹, no seeds capsule⁻¹, seed yield plant⁻¹ and 1000 seed weight were higher in the early date of sowing (Verma and Pathak, 1993). The oil content was higher at the early

date of sowing thereafter it was declined with delay in sowing (Rajput and Gautam,1993). Capsule plant⁻¹ were reduced significantly with delayed sowing. So optimum date of sowing is important for obtaining maximum yield of linseed.

The meteorological parameters play an important role in deciding the fate of the crop, because these strongly influence the physiological expression of genetic potential of the crop. It is well known that yield from any given crop or cultivar depends on the availability of certain optimum condition of solar radiation, temperature, heat units etc. during different growth stages of the crop (Doorenbos and Pruit,1977).

1.3 Cultivars:

Recent advances in breeding technology evolved number of cultivars by State Agricultural Universities which can withstand good production potential. The research efforts made by the AICRP on linseed improvement have culminated the development of 45 high yielding cultivars (38 seed and 7 dual purpose types). The increase in production and productivity indicated the impact of improved cultivars coupled with better technologies including favourable environments. The sound and viable transfer of technology process is highly adoptable to achieve a vast unexploited yield reservoir in improved linseed cultivars. Dual-purpose linseed cultivars (seed and fibre producing) can compete well in terms of net returns with any other *rabi* crop.

The linseed production can be remarkably increased, provided the adoption of improved technology and also by providing congenial weather condition throughout the crop life cycle. The weather requirement of the crop varies during the various phonological growth stages. However, the information on crop weather relationship in linseed crop is meager.

To know the different development period, plant growth, seed yield and yield components of flax there is need to explore the effect of different sowing dates and varieties of flax seed .With this study in view, the present investigation entitled “Effect of weather parameters on linseed (*Linum usitatissimum* L.) varieties under extended sowing times” is undertaken with the following objectives:

- 1.To find out suitable variety of linseed during *rabi* season.
- 2.To find out suitable meteorological week for sowing of linseed.
- 3.To study the effect of weather parameters on growth and yield of linseed under extended sowing times.
- 4.To find out the effect of thermal indices on linseed varieties under extended sowing times.

2.REVIEW OF LITERATURE

The relevant research work carried out at various places in India and abroad on linseed crop under varying agro-climatic conditions on growth, yield and quality of produce in relation to weather parameters by various research workers are collected and summarized in this chapter under appropriate headings.

2.1 Sowing time :

2.1.1 Effect of sowing time on growth and yield of linseed:

Bhatt (1965) conducted field experiment to study the appropriate sowing time in M.P. He observed that the crop sown on 9th and 20th October gave significantly higher yield over the late sown crop on 29th October and 8th November. On an average, the net gain by sowing the crop during the first fortnight of October was over 125 kg ha⁻¹ higher than the latest sown crop (8th Nov.) in linseed.

Mathur *et al.* (1984) conducted field experiment to study the effect of date of sowing on the incidence of *Dasineuralini* Branes (Diptera : cecidomyidae) and yield of linseed and it was found that maximum yield (1.387 kg plot⁻¹) was obtained with the sowing of crop on 18th October to 5th November . The lowest yield (0.607 kg plot⁻¹) was recorded when the crop was sown on 15th November.

Sheppard and Bates (1988) reported that earlier seeding resulted in the grearest seed yields and largest response to nitrogen in linseed Later seeding significantly decreased both the mean yields and response to seed yield to nitrogen. Plant density is greater at late sowing date.

Tomar and Mishra.(1991) conducted field experiments on performance of some linseed cultivars on different date of sowing under rainfed condition. They reported that the highest yield of 11.8 q ha⁻¹ was

recorded from the earliest date of sowing, when data were pooled over years. The growth parameters like plant height, number of primary and secondary branches and yield attributing characters viz, number of capsules, seed capsule⁻¹, seed and straw yields plant⁻¹, test weight and harvest index were the highest in the first date of sowing. However, the differences in harvest index were non significant in 1985-86.

Easson and Long (1992) conducted experiment in North Ireland and showed that flax planted in late produced the highest straw yields. Per cent emergence is correlated with the number of degrees over 5°C accumulated during first weeks after planting and leads to various straw yields. Plant height varied with planting with 1st May, but decreased with plantings after 1st May.

Sultana (1992) from France and Belgium noted that delayed in planting of flax decreased the plant height and increased plant height from March and May. This experiment showed the planting height reduced after late planting.

Rajput and Gautam (1993) studied the response of sowing date and nitrogen levels on growth, yield and quality of linseed during winter season and revealed that early sown crop (10th November) recorded 58.4 and 62.1 per cent higher seed yield over late sown crop (10th December) during first and second years, respectively. The highest seed yield of 1150 kg ha⁻¹ was recorded in 10th November sown crop but it was at par with 25th October (1060 kg ha⁻¹) and 25th November (1040 kg ha⁻¹) sown crop during first year.

Dixit *et al.* (1994) conducted a field experiment at Madhya Pradesh and reported that crop sown at 5th-11th November, 22nd-28th October and 15th-21st October, respectively, with temperature 25.2 °C gave the highest linseed seed yield.

Shahidullah *et al.* (1997) performed a field experiment at Bangladesh and noticed that the greatest seed yield was obtained by sowing on 3rd November and it decreased gradually with delay in sowing.

Abdul EL-Dayem *et al.* (1998) conducted a field experiment at Cairo, (Egypt) and concluded that there were significant differences in plant height, technical length length of top branching zone and stem diameter due to sowing date (15th and 30th October, 15th and 30th November) in linseed.

Giri (2000) from New Delhi conducted a field experiment and opined that sunflower sown in the third week of October produced higher dry matter per plant than the crop sown in November third week, but the higher yield of sunflower was obtained when it was sown in third week of November.

Naik and Satapathy (2000) carried out a field experiment at Jashipur (Orissa) and reported that there was improvement in the growth characters of linseed as plant height, days to 50% flowering, number of primary branches per plant and days to maturity under late sown condition of linseed.

Yadav *et al.* (2002) from Uttar Pradesh (India) conducted a field experiment and found that crop sown at 1st-8th November resulted in the greatest seed yield (2164, 1949 and 2053 kg/ha), number of capsules per plant (76.1, 74.3 and 68.4), number of grains per capsule (8.2, 7.7 and 7.6).

Kalita *et al.* (2005) conducted field experiment to study the effect of date of sowing and tillage on soil properties, nutrient uptake and yield of linseed grown in winter rice fallows and observed that the crop sown on 10th November recorded significantly higher seed yield and total N, P and K uptake in both the years.

Impact of sowing time cum newly released cultivars of linseed was studied at Palampur and it was observed that seed yield (988 kg ha^{-1}) and gross monetary returns ($\text{Rs.}19767 \text{ ha}^{-1}$) were significantly superior when crop was sown during November 1st week. But the crop sown during October last week was at par in these regards. The reduction in the seed yield was observed 26.2 % in November last week sown crop as compared to November 1st week sown crop (Anonymous, 2006).

Impact of sowing time on newly released cultivars of linseed was studied at Nagpur and it was revealed that the linseed crop sown during October last week to November 1st week produced significantly higher seed yield (1070 kg ha^{-1}) November 2nd and last week and net monetary returns ($\text{Rs.}14980 \text{ ha}^{-1}$) as compared to late sown crop (Anonymous, 2006).

Chauhan *et al.* (2008) conducted field experiment at Agriculture Research Farm, Bundelkhand (U.P.) during winter season to study three sowing dates (10th Oct, 25th Oct and 10th Nov.) and four varieties Subhra, Neelam, Sweta and Laxmi of linseed and found that sowing on 25th October with Neelam variety recorded significantly higher yield.

Saad Ahmed Mohamed Al-Doori (2012) observed the sowing of flax crop on the first November gave the highest number of capsules per plant, number of seeds per capsule, weight of thousand seed, seed, oil yield per hectare. Sowing on the first November surpassed those sown on mid November in seed yield per hectare by 20.32% and 20.7% as well as sown on mid October by 17.8% and 12.6% in the first and second seasons, respectively.

2.1.2 Effect of sowing times on quality of linseed:

Singh (1968) studied the effect of varying levels of nitrogen and date of sowing on yield and quality of linseed (*Linum usitatissimum* L.) and revealed that the number of capsules plant⁻¹, number of seeds capsule⁻¹, diameter capsule⁻¹, weight capsule⁻¹ and test weight were adversely affected due to delay in planting. Early sowing (21st October) reported an increase in yield to the tune of 50 per cent over late planting (4th November.)

Neenam and Devereux (1973) conducted experiment in North Ireland showed that flax planted in late March or early April produced the highest straw yields and later planting decreased the yield. Flax is cool growing crop so maturity also enhances.

Prasad and Sharma (1975) found that there is maximum number of capsules plant⁻¹ with full irrigation and revealed that maximum seed numbers per capsule were produced with full irrigation when sown on April 20th and on May 10th in linseed.

Reddy (1983) conducted a field experiment on response of linseed cultivars to varying fertility levels under irrigation and observed that oil yields were higher in T-126, Jawahar-17 and S-36.

Rajput *et al.* (1993) performed a field experiment at Madhya Pradesh and reported that the optimum sowing date was 10th November. Seed oil content decreased and protein content increased as the sowing was delayed after 10th October.

Verma and Pathak (1993) conducted field experiment on response of linseed (*Linum usitatissimum* L.) cultivars to different dates of sowing and reported that the highest seed yield was obtained in D₂ (18th October) closely followed by D₃ (28th October). The reduction in seed yield in subsequent sowing beyond D₃ (28th October) was due to the shorter reproductive period in the late sown crop.

Singh (2001) observed that delayed sowing enhanced maturity of linseed and reduction in yield was observed due to less time for proper vegetative growth and development

2.2 Impact of weather during different phenophages of linseed crop:

Berger (1969) from Europe observed that flax required abundant moisture and cool weather during the growing season which enhanced the maturity. Plant survive a few degrees of frost with -4°C temperature so early planting is possible. Usually planting is favourable in March but not later than April.

Kaul *et al.* (1994) conducted experiment in Germany and found that a late sowing date and high plant density combined with warm and dry weather conditions led to reduced vegetative plant growth in linseed. A reduction in vegetative growth and better straw yield achieved with late seeding date and warm dry weather conditions.

Casa *et al.* (1999) studied the environmental effects on linseed yield and growth of flax at different temperature. Sum, from emergence to beginning of flowering calculated using the mean daily temperature, averaged 382°Cd (degree days). The maximum LAI which coincided with full flowering was reached in 1997 and 1998 at about 400°Cd which took 16 days lesser, from emergence in 1998. The higher temperature and dry conditions during vegetative development phase caused shortening in the growing cycle as compared to cooler year.

Gourangakar and Chakravarty (1999) conducted field experiment on thermal growth rate, heat and radiation utilization efficiency of Brassica under semi arid environment. They observed that the seed filing and maturity stages of crop growth of late sown crop (2nd week of Nov.) experienced $2.5\text{-}3.0^{\circ}\text{C}$ higher temperature as compared to early sown crop (2nd fortnight of October). Study also revealed that there was significant correlation between GDD and crop growth parameters

with correlation coefficient ranging between 0.58 and 0.98 among different cultivars and sowing dates.

Mokashi (1999) conducted experiment on thermal requirement in sunflower, red gram intercropping in the scarcity zone of Maharashtra state and revealed that the accumulated heat units and number of days for reaching various growth stages decreased with successive delay in sowing. The variation in accumulated heat unit and number of days to reach various growth stages did not indicate any definite trend. The crop sown earlier received maximum thermal energy than late sown crop during all the years of experimentation. The heat unit required to attain the harvesting stage marginally differ within the year under all sowing dates as evidenced from coefficient of variation.

Agrawal *et al.* (2002) studied on thermal requirement of sunflower plant type, three dates of spring planting and observed that GDD was higher in D₁ and D₂ planting than D₃ and its mean value was 3435, 2288 and 2172 °Cd, respectively. However different genotypes were similar in GDD requirement.

Siddique *et al.* (2002) conducted experiment at Dhaka (Bangladesh). The experiment was conducted to test range of sowing dates covering a wide range of environmental situation. They found that delayed sowing (March, April, May, June, August, September) of flax reduced 30 % yield components and seed yield because of rise in temperature 22°C and long photoperiod. Vegetative growth was very rapid and hence flax plant mature quickly.

Singh (2002) studied the effect of intercropping on reflected photo synthetically active radiation (RPR) in rainfed crop and concluded that RPR values increased with increase in crop age up to 42 days and decreased with decreasing crop age (56-70 DAS) and again increased at

98th day. In general, RPR values were the highest during the initial stage of crop growth owing to more exposure of soil due to less LAI.

Singh (2002) b studied for evaluating intercropping system on the basis of transmitted PAR (TPAR). They observed that the measurement on TPAR for all the intercropping and sole sorghum treatment reported an increasing trend both, under sole and intercropping system. The highest TPAR of 59.5 % was observed on the 28th DAS due to less leaf area index (LAI). As leaf area index increased TPAR decreased.

Neog and Chakravarty (2005) conducted experiment on thermal unit and phonological model for *Brassica juncea* and revealed that decreasing trend in accumulated GDD was observed with successive delay in sowing of crop.

Naresh Kumar (2005) studied on thermal unit requirement for leaf growth and phonological development in sunflower. He observed that GDD requirement for different phonological stages in different sowing time varied more during seed filling period than the vegetative period.

Vrishali (2005) conducted field experiment on relationship of LAI and biomass of soybean with agroclimatic indices. They revealed that the GDD and HTU for soybean season reported significant correlation with LAI as well as biomass.

Shaikh *et al.* (2008) conducted a field experiment at Latur (Maharashtra) noticed that delay in sowing of cultivars Kiran, Garima and RLC-4 showed differences in number of days to maturity and growing degree days from sowing to maturity in linseed.

2.3 Study on the individual weather element prevailed during different phonological growth stages.

Casa *et al* (1999) studied on the environmental effects on linseed yield and growth of flax at different plant densities and concluded that the environmental factor, most likely to affect yield were high temperature due to its effect on development rate and the consequent shortening of the growing cycle and perhaps water shortage. The foliage duration was more important than the maximum leaf area index.

Rossini and Casa (2003) conducted the experiment on influence of sowing time and harvest time on fibre flax *i.e.* linseed (*Linum usitatissimum* L.) in the Mediterranean environment and reported that the dry and warm condition occurring from late spring onwards tended to cause shortening the growth cycle with a negative impact on seed and fibre yield and quality.

Rajendra Prasad (2004) concluded that oilseed crop needs about 25 to 30⁰ temperature during germination of seed and about 15⁰C to 20⁰C during seed formation. However, the fibre crop required still lower temperature and high humidity. He further concluded that flax may damage at temperature between –8⁰C and 3⁰C in the seedling stage and a light freeze of –1⁰C may cause injury during the green boll stage.

Mondal *et al.* (2005) concluded that the temperature during vegetative development of crop should be moderate or cool. High temperature above 32⁰C accompanied with drought during flowering stage reduced the yield, oil content and the quality of oil. Moderate temperature ranging between 21⁰C to 26⁰C are ideal.

2.4 Effect of cultivars on growth and yield of linseed:

While studying the performance of high yield and disease resistant varieties of linseed from different agroclimatic situation under Jabalpur (M.P.) condition, Vyas and Prasad (1980) observed that SPS-49-2 and SPS-30-5 which were bold seed type gave higher grain yield of 1275 and 1150 kg/ha, respectively.

Reddy (1983) conducted a field experiment on response of linseed cultivars to varying fertility levels under irrigation and revealed that Cv. T-126, Jawahar-17 and S-36 produced significantly higher seed yield which was 65.0, 62.5 and 52.5 per cent more, respectively when compared to No.55.

A multilocal trial under irrigated conditions was carried at AICRPO, Solapur (M.S.) and Tikamgarh (M.P.). during 1982-83 on linseed. It was observed that the Cv. SPS-23-10 gave higher seed yield compared with SPS-49-2 (Anonymous, 1984).

Dubey and Srivastava (1986) studied on three new varieties of linseed named Garima, Sweta and Shubhra at the C. S. Azad University of Agriculture and Technology, Kanpur and concluded that Garima performed well with mean seed and oil yield of 1491 and 632 kg/ha, respectively, under irrigated situation. It has outyielded the best check Neelum and T-397 in seed and oil yields, respectively, by margin of over 18 per cent.

Sharma and Roy (1987) studied the effect of sowing dates and fertilizer on linseed and concluded that Cv. LHCK-82 gave significantly higher seed yield than other cultivars. The higher yield of LHCK- 82 was due to better expression of yield attributing characters.

Tomar and Mishra (1991) conducted experiment on performance of some linseed cultivars on different dates of sowing under

rainfed condition and reported that Cv. RLC-3 gave the highest seed yield (1236 kg ha⁻¹) followed by J-23-10 (1043 kg ha⁻¹). The growth and yield attributes reported maximum expression in the Cv. RLC-3.

Dixit *et al.* (1994) conducted field experiment on assessment of flexibility of sowing time of linseed cultivars under double cropping system in Tawa command and concluded that the Cv. R-552 of 119 days gave the highest yield over Jawahar-23 (125 days) and R-17 (119 days).

Verma and Pathak (1993) studied the response of linseed cultivars to different dates of sowing during winter season and reported that Garima recorded significantly higher seed yield than Neelum and Shubhra.

Sharma *et al.*, (1995) studied the performance of linseed cultivars under varying dates of sowing in Kullu valley and concluded that the cultivars Himalini and Janaki gave significantly higher yield over Jeevan and KL-1 in 1986-87 but in 1987-88 No significant differences in yield were obtained between Himalini, Janak and Jeevan.

Khare *et al.* (1999) conducted the experiment on relative performance of linseed cultivars under different sowing management in rainfed condition and observed that the Cv. Kiran exceeded all Cv. in term of seed yield and profit, mainly due to more branches plant⁻¹ and capsules plant⁻¹.

An experiment conducted by Pali and Tripathi (2000) on performance of linseed (*Linum usitatissimum* L.) cultivars under varying sowing time and fertilizer management in rainfed condition and reported and that Cv. Kiran gave the maximum seed yield followed by R-552, RLC-29 by producing more branches plant⁻¹, capsule plant⁻¹ and seed capsule⁻¹ mainly contributed to the seed yield.

Dubey (2001) conducted the experiment on response of late planted linseed (*Linum usitatissimum* L.) cultivars to nitrogen levels

under rainfed condition Regional Agril. Research station, Sagar and observed that RLC-29 (Sheetal) recorded significantly higher plant population, dry plant biomass, branches, capsule number and their weight (g) except plant height in T-397, seed capsule-1 in (SLS-21, SLS-7 and T-397), harvest index in (SLS-7, SLS-9).

Verma *et al.* (2005). Conducted field experiment on evaluation of improved management technologies and linseed cultivars in salt affected soil under rainfed condition at Kanpur it was observed that variety padmini and PKVNL-260 having markedly higher dry matter, branches and capsule per plant with dwarf plant utilized soil moisture more efficiently under rainfed condition and showed better tolerance to salts compared to Sweta and Bijuri local.

Impact of sowing time-cum-newly released cultivars of linseed was studied at Faizabad and it was concluded that the linseed Cv. Garima exceeded Shubhra, Shekhar and T-397 with regards to seed yield. The magnitude of superiority of Garima over Shubhra, Shekhar and T-397 was found to be significant by a margin of 24.23, 12.07 and 45.07 per cent, respectively, (Anonymous, 2006).

Impact of sowing time-cum-newly released cultivars of linseed was studied at Powarkheda and it was revealed that seed yield produced by Kiran Cultivar was significantly higher over JLS-9, J-23 and Kartika (Anonymous, 2006).

Rao *et al.* (2007) conducted experiment on stability behavior of some linseed (*Linum usitatissimum* L.) genotype under environmental variability and showed that genotype Kiran required 53 days to flower, 105 days to mature and more 1000 seed weight (4.66 g) and 1.34 g seed yield per plant.

Mohammad *et al.* (2012) conducted experiment on different sowing dates and spring varieties during spring. Seed and stover

yields were significantly influenced due to various sowing dates and genotypes of flax seed. It was observed that high temperature effects on pollination, ovary survival or seed development which ultimately reflects into 40% reduction in yield.

3. MATERIAL AND METHODS

The present investigation entitled, “ Effect of weather parameters on *linseed* varieties under extended sowing times” was carried during *rabi*, 2013. This chapter deals with the materials used and methods adopted for conduct of present investigation.

3.1 Materials

3.1.1 Experimental site

The field experiment was conducted during *rabi*, 2013 at Department of Agricultural Meteorology Farm, Centre of Advanced Faculty Training (CAFT) in Agricultural Meteorology, College of Agriculture, Pune, Maharashtra State (India).

3.1.2 Soil

The topography of the experimental field was uniform, leveled and with uniform in depth up to 60 cm. The soil comes under order vertisol (medium black), clayey in texture.

In order to know the physical and chemical properties of experimental field, representative composite samples were collected from 0-30 cm depth at 5 randomly selected spots in zig-zag fashion before sowing with the help of screw auger. These samples was prepared for determining physical and chemical properties of the experimental field.

The analytical methods used for soil and plant analysis are presented in Table 1. The data in Table 2 revealed that the soil of experimental field was clay loam in texture, normal in reaction (pH 7.7) with low available nitrogen ($173.67 \text{ kg ha}^{-1}$), medium available phosphorus (29.56 kg ha^{-1}) and high available potassium ($467.00 \text{ kg ha}^{-1}$)

Table 1. Analytical methods used for soil and plant analysis

Sr. No.	Parameters	Method adopted	Reference
A.	Soil analysis		
1	Particle size analysis	Hydrometer method	Bouyoucos, (1962)
2	Textural class	Hydrometer method	Bouyoucos, (1962)
3	pH	Potentiometric	Page <i>et al.</i> (1982)
4	E.C. (dSm^{-1})	Conductometric	Page <i>et al.</i> (1982)
5	Organic carbon (%)	Wet oxidation method	Nelson and Sommers,(1982)
6	Available Nitrogen (kg ha^{-1})	Modified alkaline permanganate method	Sahrawat and Burford, (1982)
7	Available Phosphorus (kg ha^{-1})	Olsen's method	Olsen and Sommers., (1982)
8	Available Potassium (kg ha^{-1})	Neutral normal ammonium acetate extraction method	Jackson, (1973)
B.	Plant analysis		
1	Nitrogen	Micro-Kjeldhal method	(A.O.A.C., 1980)
2	Phosphorus	Vando-molybdate yellow colour method in nitric acid system	Jackson, (1973)
3	Potassium	Flame photometric method	Jackson, (1973)

Table 2. Physical and chemical properties of soil from the experimental field (0-30 cm)

Sr. No.	Characters	Content
A.	Physical properties	
1.	Coarse sand (%)	7.20
2.	Fine sand (%)	27.45
3.	Silt (%)	24.68
4.	Clay (%)	40.54
5.	Texture	clay loam
B.	Chemical properties	
1.	Available nitrogen (kg ha^{-1})	162.67
2.	Available phosphorus (kg ha^{-1})	29.56
3.	Available potassium (kg ha^{-1})	467.00
4.	pH	7.1
5.	E.C. (dSm^{-1})	0.32
6.	Organic carbon (%)	0.53

3.1.3 Climate

3.1.3.1 General

The area is lying on the eastern side of Western Ghats. Climatologically it comes under semi-arid, sub-tropical region and agro climatologically is identified as plain zone of Maharashtra. The geographic location of the site (Pune) was $18^{\circ} 32'$ latitude; $73^{\circ} 51'E$, Longitude 557.7 meters above mean sea level (MSL). It has an average rainfall of 675 mm, which is concentrated mostly during months from June to September. i.e. from south-west monsoon. The remaining rainfall received during post monsoon period from October to December (North-East monsoon).

3.1.3.2 Season

The climatic conditions prevailed during the period of present investigation; the meteorological data were recorded on important weather parameters during *rabi*, 2013 are presented in Table 3 .

The annual mean maximum temperature during growing period (2013-14) was 32°C with a ranged from 27°C to 40.2°C. The annual mean minimum temperature during growing period (2013-14) was ranged from 7.3°C to 18.5°C. The annual mean relative humidity at 7.30 hrs (RH-I) ranged from 54 to 95 % and at 14.30 hrs (RH-II) ranged from 17 to 84%. The annual average solar radiation was 20.50 M J m⁻² d⁻¹. The average annual wind speed was 5.3 km/h. The sunshine hours was recorded from 6.2 to 9.5 during the crop growth period and No rainy days were occurred during crop growth period.

**Table 3. Meteorological data recorded during the experimental period
(Oct,2013 to March,2014)**

MW	Mean Temp. °C		Relative humidity(%)		Wind speed km/hr ⁻¹	Rainfall (mm)	Rainy day	Evapo Ration (mm)	BSS (hrs day ⁻¹)
	Max.	Min.	RH I	RH					
44	31.8	18.1	87	43	1.8	0.0	-	4.8	8.5
45	30.2	15.3	89	40	1.8	0.0	-	4.5	7.9
46	29.2	12.5	92	36	1.8	0.0	-	4.5	9.0
47	31.2	14.0	92	37	1.5	0.0	-	4.0	9.0
48	29.8	18.5	94	53	1.8	2.1	-	3.3	6.3
49	29.1	13.1	94	36	1.5	0.5	-	3.4	7.8
50	29.3	7.3	94	26	1.3	0.0	-	3.5	9.5
51	29.5	8.5	94	31	1.4	0.0	-	3.4	9.3
52	28.7	12.9	97	42	1.7	0.0	-	3.2	7.5
1	29.0	12.2	92	41	2.0	0.0	-	3.7	8.6
2	30.2	12.0	94	34	1.9	0.0	-	4.0	8.9
3	29.8	12.7	92	37	2.4	0.0	-	4.2	7.9
4	29.2	14.5	90	40	1.8	0.0	-	3.4	6.2
5	29.7	11.3	93	34	1.9	0.0	-	4.1	8.9
6	32.0	10.6	90	20	2.9	0.0	-	4.2	9.5
7	30.0	12.8	88	30	4.9	0.0	-	5.1	9.5
8	31.1	15.0	89	35	3.8	0.0	-	4.6	8.4
9	30.6	14.0	87	33	4.3	0.0	-	5.8	9.3
10	31.2	16.4	87	34	4.0	0.3	-	5.5	7.9

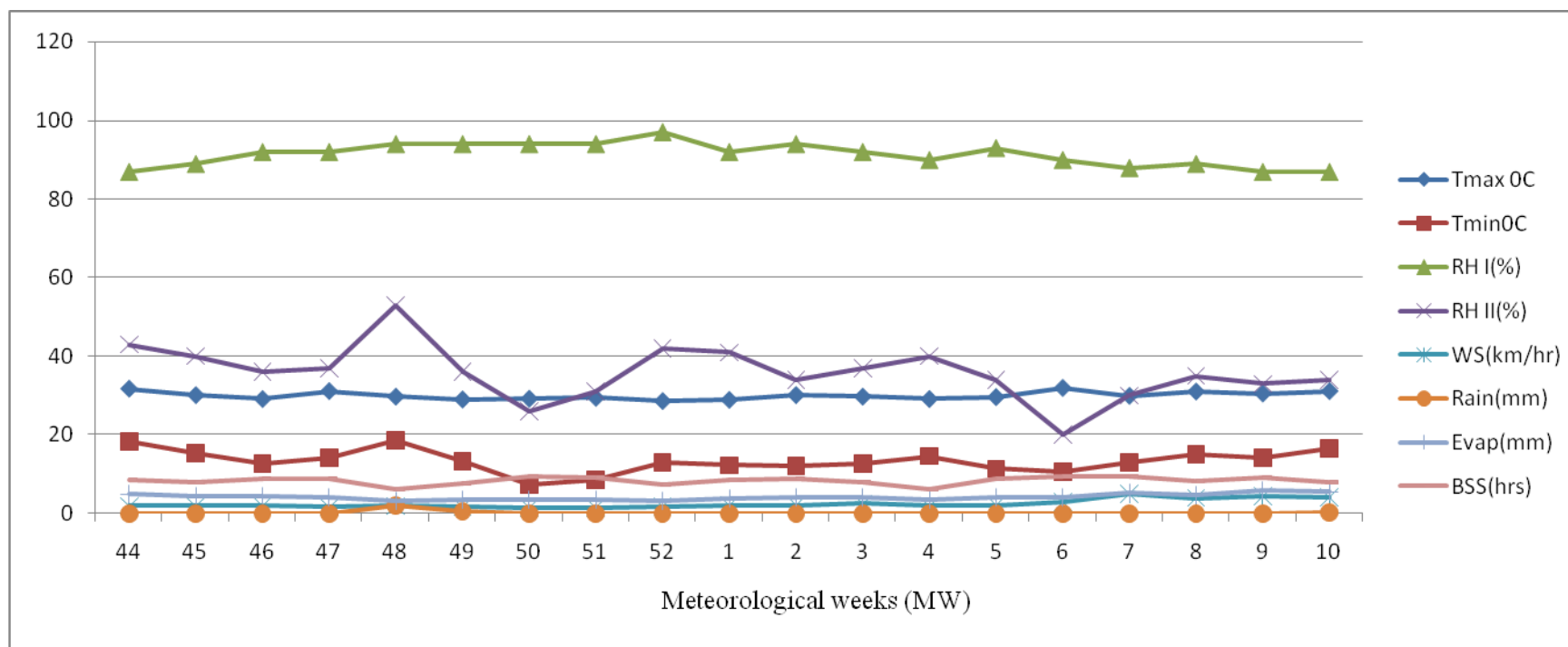


Fig.1.Climatic condition during experimental period (Oct,2013 to March,2014)

3.1.4. Cropping history of the experimental field

The cropping history of experimental field for previous two years is presented in table 2

Table 4. Cropping history of the experimental field

Year	Season		
	<i>Kharif</i>	<i>Rabi</i>	Summer
2011-12	Soybean	Wheat	Fallow
2012-13	Soybean	Fallow	Fallow
2013-14	Soybean	Present investigation (linseed)	

3.2 Details of experimental Methods

3.2.1 Experimental details

The experiment was conducted in a split plot design with three replications. Fifteen treatment combinations were formed considering different sowing times and varieties in *rabi*, 2013. The details are listed below.

- a) Name of crop : Linseed
- b) Variety : As per the treatment
- c) Season : *Rabi*, 2013-14
- d) Design : Split plot
- e) Replications : Three (3)
- f) Treatment : Fifteen (15)
- g) Spacing : 30 cm x 5 cm
- h) Plot size : Gross : 3.00 x 2.4 m²
Net : 2.20 x 1.80 m²
- i) Commencement of research work : *Rabi*, 2013
- j) Sowing date : As per treatments
- k) Place of research work : Department of Agricultural Meteorology
Farm, College of Agriculture, Pune-5

a. Main plot treatment (Varieties) : V_1 - PKVNL-260

V_2 - NL-97

V_3 - Padmini

b. Sub plot treatments (Sowing times):

S_1 - 44th MW (29th Oct –4th Nov)

S_2 - 45th MW (5th –11th Nov)

S_3 - 46th MW (12th – 18th Nov)

S_4 - 47th MW (19th – 25th Nov)

S_5 - 48th MW(26th Nov–2nd Dec)

Table 5. Details of treatments along with their symbols

Treatments	Details
$T_1 - V_1S_1$	V_1 – PKVNL-260, S_1 - MW-44 (29 th Oct. – 4 th Nov.)
$T_2 - V_1S_2$	V_1 –PKVNL-260, S_2 - MW-45 (5 th – 11 th Nov.)
$T_3 - V_1S_3$	V_1 – PKVNL-260, S_3 - MW-46 (12 th – 18 th Nov.)
$T_4 - V_1S_4$	V_1 – PKVNL-260, S_4 - MW-47 (19 th – 25 th Nov.)
$T_5 - V_1S_5$	V_1 – PKVNL-260, S_5 - MW-48 (26 th Nov. – 2 nd Dec.)
$T_6 - V_2S_1$	V_2 – NL-97, S_1 - MW-44 (29 th Oct. – 4 th Nov.)
$T_7 - V_2S_2$	V_2 – NL-97, S_2 - MW-45 (5 th –11 th Nov.)
$T_8 - V_2S_3$	V_2 – NL-97, S_3 - MW-46 (12 th – 18 th Nov.)
$T_9 - V_2S_4$	V_2 – NL-97, S_4 - MW-47 (19 th – 25 th Nov.)
$T_{10} - V_2S_5$	V_2 – NL-97, S_5 - MW-48 (26 th Nov. – 2 nd Dec.)
$T_{11} - V_3S_1$	V_3 – Padmini, S_1 - MW-44 (29 th Oct. – 4 th Nov.)
$T_{12} - V_3S_2$	V_3 – Padmini, S_2 - MW-45 (5 th –11 th Nov.)
$T_{13} - V_3S_3$	V_3 – Padmini, S_3 - MW-46 (12 th – 18 th Nov.)
$T_{14} - V_3S_4$	V_3 – Padmini, S_4 - MW-47 (19 th – 25 th Nov.)
$T_{15} - V_3S_5$	V_3 – Padmini, S_5 - MW-48 (26 th Nov. – 2 nd Dec.)

3.2.2 Cultural operations

Date wise schedule of the cultural operations in the experimental field of linseed during period of experimentation are given in Table 4.

3.2.2.1 Field layout

Flat beds and irrigation channels were prepared manually as per the plan of layout (Fig. 2).

3.2.2.2 Application of fertilizer

A basal dose of 25 kg P_2O_5 ha⁻¹ was applied through single super-phosphate and N dose @ 50 kg ha⁻¹ was applied through urea in two equal split doses at sowing and 30 DAS.

3.2.2.3 Sowing

The seeds were sown as per treatments and sowing was done by line, the inter row spacing was 30 cm and intra-row spacing was 5 cm.

3.2.2.4 Seeds

Cultivar PKVNL-260

This is dwarf, high yielding cultivar, maturity in 97 to 111 days. It is released for cultivation year 2009. It is resistant to alternaria, powdery mildew and budfly. The flower are of blue colour. This cultivar cross between R-552 x RLC-6 parent in pedigree breeding method. The seed are of light brown colour. It is early maturity cultivar. It is recommended ecology suitable for rabi season rainfed (last week of October) and Irrigated (first week of November). This cultivar plant height 45-63, No. of capsule per plant 59, and 8-9 branches per plant. Test weight 6.8 gm. The seed yield and oil percentage of this cultivar are 900-1800 kg/ha, 38% .([http:// www.ijcm.as.com](http://www.ijcm.as.com))

Cultivar NL-97

This is dwarf, high yielding cultivar, maturity in 105 to 115 days. It is released for cultivation year 1997. It is resistant to alternaria, powdery mildew wilt and budfly. The flower are of brown colour. This cultivar cross between R-7 x RLC-4 parent in pedigree breeding method . The seed are of light brown colour. It is medium maturity cultivar. It is recommended ecology suitable for rabi season rainfed Condition of Vidarbha region. This cultivar plant height 50-55, No. of capsule per plant 59, and 6-7 branches per plant. Test weight 6.8 gm. The seed yield and oil percentage of this cultivar are 600-1200 kg/ha, 44% . (<http://www.ijcm.as.com>)

Cultivar Padmini (LM-62)

This is dwarf, high yielding cultivar, maturity in 111 to 120 days.. It is resistant to rust, powdery mildew and blight. The flower are of blue colour. This cultivar cross between DPL-20 X Neelum parent in pedigree breeding method . The seed are of light brown colour. It is recommended ecology suitable for rabi season rainfed condition. This cultivar plant height 50-55 cm , No. of capsule per plant 53, and 6-7 branches per plant. Test weight 6.3 gm. The seed yield and oil percentage of this ncultivar are 900-1500 kg/ha, 42.6 %. ([http:// www.ijcm.as.com](http://www.ijcm.as.com))

3.2.2.5 Gap filling and thinning

To maintain optimum plant population, gap filling was carried out immediately after germination and after 10 days thinning was carried by maintained 5 cm intra plant spacing . only one healthy plant was kept per hill.

3.2.2.6 Hand weeding

Two hand weedings were given to keep the plots weed free at 30 and 50 days after sowing of crop.

Table 6. Schedule of field operations carried out during *rabi*, 2013

Sr. No.	Name of operation	Frequency	Sowing times				
			S ₁ (MW 44)	S ₂ (MW 45)	S ₃ (MW 46)	S ₄ (MW 47)	S ₅ (MW 48)
A.	Preparatory tillage						
1.	Ploughing	1	20.10.2013	20.10.2013	20.10.2013	20.10.2013	20.10.2013
2.	Harrowing	1	22.10.2013	22.10.2013	22.10.2013	22.10.2013	22.10.2013
3.	Field layout	1	28.10.2013	28.10.2013	28.10.2013	28.10.2013	28.10.2013
B.	Sowing and fertilizer application						
1.	Fertilizer (basal) and (top dressing) application	1	30.10.2013 20.10.2013	06.11.2013 26.10.2013	13.11.2013 02.12.2013	20.11.2013 10.12.2013	27.11.2013 17.12.2013
2.	Seed treatment with <i>Azotobactor</i> and PSB	1	30.10.2013	06.11.2013	13.11.2013	20.11.2013	27.11.2013
3.	Sowing	1	30.10.2013	06.11.2013	13.11.2013	20.11.2013	27.11.2013
C.	Post sowing operations						
1.	Gap filling	1	12.11.2013	20.11.2013	27.11.2013	04.12.2013	11.12.2013
2.	Thinning	1	12.11.2013	20.11.2013	27.11.2013	04.12.2013	11.12.2013
3.	Hand weeding	2	22.11.2013 20.12.2013	27.11.2013 26.12.2013	28.11.2013 03.01.2013	06.12.2013 10.01.2013	14.12.2013 17.01.2013
4.	Irrigation	8	10 days interval	10 days interval	10 days interval	10 days interval	10 days interval
D.	Harvesting	1	18.02.2014	24.02.2014	03.03.2014	10.03.2014	15.03.2014
E.	Threshing	1	20.02.2014	26.02.2014	05.03.2014	12.03.2014	18.03.2014

3.2.2.7 Irrigation

Total depth of irrigation was 56 cm with 8 irrigations as per requirement.

3.2.2.8 Plant protection measures

Plant protection measures were not undertaken as there was no any pest or disease incidence was observed during crop growth period of linseed.

3.2.2.9 Harvesting and threshing

The linseed crop was harvested when it was completely matured. The observational plants were harvested carefully first, border rows plant on either sides of the gross plot area were removed and then plants from net plot area were harvested. The harvesting was done with the help of sickle .The produce were tied in bundles plot wise and carried to threshing yard for sun drying. After complete drying the produce from each net plot area was threshed, winnowed and cleaned separately and weight was recorded for each net plot.

3.2.3 Biometric observations

The details of the biometric observations recorded are mentioned in Table 7.

3.2.3.1 Sampling technique

The various biometric observations were recorded on five randomly selected plants of linseed from each net plot. Pegs were fixed near the selected plants by tying with tags for easy identification. All the growth observations were recorded periodically at an interval of 14 days to till harvest. The details of observations recorded during the season are presented in Table 7.

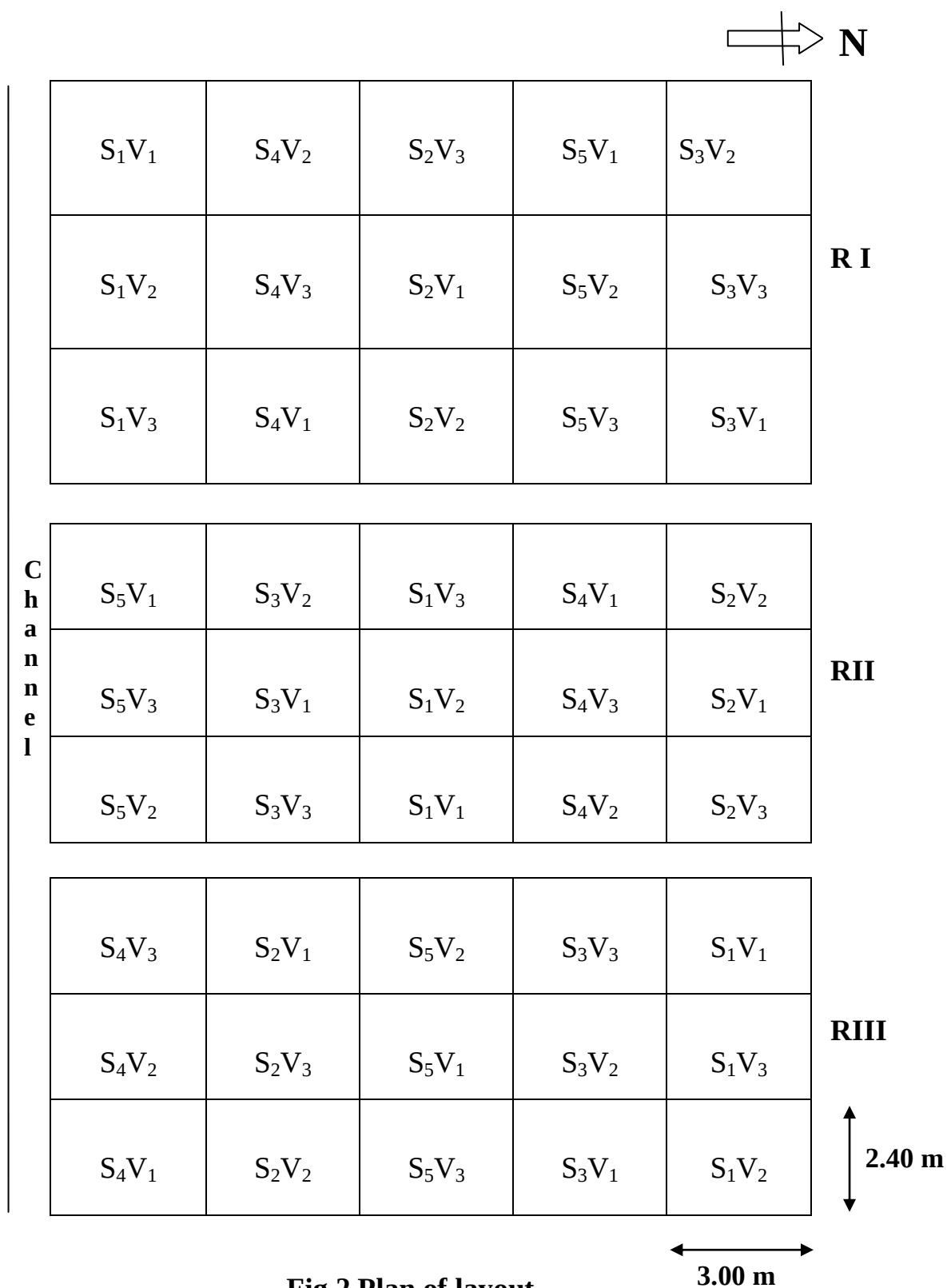


Fig.2 Plan of layout

Design : Split plot plot size i) Gross: $3.00 \times 2.40 \text{ m}^2$

Treatment : 15 ii) Net : $2.20 \times 1.80 \text{ m}^2$

Replication : 3

3.2.3.2 Plant count

The initial and final plant count was recorded by counting all the plants from each net plot at 14th days after sowing and at harvest of the crop, respectively.

3.2.3.3 Growth studies

The details regarding various growth observations are as follows:

Table 7. Schedule of biometric observation

Sr. No.	Particulars	Frequency	Days after sowing	Size of sample
1	2	3	4	5
A	Plant count			
1	Initial	1	14 DAS	All plants from each net plot
2	Final	1	At harvest	
B	Growth characters			
1	Plant height (cm)	7	14,28,42,56,70,84 DAS and at harvest	5 plants
2	Plant spread(cm)	7	14,28,42,56,70,84 DAS and at harvest	5 plants
3	No. of branches plant ⁻¹	7	14,28,42,56,70,84 DAS and at harvest	5 plants
4	Days to 50% flowering	1	At flowering Stage	Net plot
5	Days to maturity	1	At maturity Stage	Net plot
6	Dry matter plant ⁻¹	7	14,28,42,56,70,84	5 plants

			DAS and at harvest	
C.	Yield contributing characters			
1.	No. of capsules plant ⁻¹	1	At harvest	5 plants
2	No. of seeds capsule ⁻¹	1	At harvest	5 plants
3	Test weight (g)	1	At harvest	
4	Weight of seed plant ⁻¹ (g)	1	At harvest	5 plants
D	Yield (q ha⁻¹)			
1	Seed yield	At harvest		
2	Stover yield	At harvest		

E	Meteorological observations			
1.	Thermal indices			
2.	Measurements of components of PAR $\mu\text{mol m}^2\text{s}^{-1}$			
2.1	Measurement of incident PAR			
2.2	Measurement of transmitted PAR			
2.3	Determination of intercepted PAR			
2.4	Measurement of RPAR by Canopy + Soil			
3.	Evaporation (mm)			
4.	Temperature (Tmax & Tmin) °C			
5.	Relative Humidity (RH I & RH II) (%)			
6.	Bright sunshine hours			
7.	Rainfall (mm)			

a. Plant height (cm)

The plant height was measured from the ground level up to apical growing point. Observations were started from 14th days after sowing and were subsequently recorded at an interval of 14 days up to harvest.

b. Plant spread (cm)

Plant spread was recorded at an interval of 14 days from 14th, 28th, 42th, 56th, 70th, 84th DAS and at harvest. Plant spread (cm) was recorded by measuring the maximum horizontal space occupied by the plant between tips of two extreme leaves either side from the observational plant.

c. Number of branches plant⁻¹

Numbers of branches were recorded periodically at 14 days interval from 14th, 28th, 42th, 56th, 70th, 84th DAS and at harvest.

d. Days to 50% flowering

The total number of days to flowering was recorded by observing 50% flowered plants from net plot.

e. Dry matter

In order to study the dry matter accumulation, periodically at 14 days interval from 14th, 28th, 42th, 56th, 70th, 84th DAS and at harvest from each net plot. The plants were cut at the ground level and kept for air sun drying and then in an oven at 60⁰C temperature till constant weight were obtained.

f. Days to maturity

The total number of days from sowing to attain full maturity was recorded by considering all the plants from net plots and reported.



Plate .1.General view of experimental plot

3.2.3.4 Yield contributing characters

a. Number of capsules plant⁻¹

At harvest, the number of capsules of five observational plants was recorded.

b. Number of seeds capsule⁻¹

The number of seeds per capsule of the five plants under observation was counted and from this, the mean number of seeds per capsule was calculated at harvest.

c. Weight of dry capsules plant⁻¹ (g)

At harvest, the weight of capsules of five observational plants was recorded and reported on plant basis.

d. Weight of seeds plant⁻¹

At harvest, the seed yield of five observational plants was recorded and from this per plant seed weight was calculated.

e. Thousand seed weight i.e. Test weight

A representative sample was taken from the produce of each treatment and from the sample, thousand grains were counted and weight was recorded for each treatment.

3.2.3.5 Yield of linseed

a. Grain yield

The produce was dried in sun for a week. After threshing, the seeds were cleaned from dried leaves, soil and other foreign material. The yield of seed per net plot (Kg/ha) was recorded and then converted on hectare basis by multiplying with hectare factor.

b. Straw yield

Yield of straw (kg) per net plot was obtained by subtracting the yield of seeds per plot from the yield of total dry produce of net per plot and then converted to hectare basis.

c. Biological yield

Biological yield (kg) on net per plot basis was obtained by adding the yield of seeds per plot and the yield of total dry produce per plot and then converted to hectare basis.

3.3 Micrometeorological observations

3.3.1 Growing degree days (GDD)

Temperature is a major environmental factor that determines the rate of plant development. The temperature requirement and range of optimum temperature varied with species and genotype. The thermal response of genotype can be quantified by using the heat unit or thermal time concept. There is high probability of successfully predicting the development of linseed by heat unit.

Thermal time or growing degree days were calculated according to the equation. (Mali *et al.* 2000).

$$\text{G.D.D.} = \sum_{i=1}^n [(T_{\max.} + T_{\min.})/2 - T_b]$$

Where,

G.D.D.	=	Growing degree days
$T_{\max.}$	=	Daily maximum temperature of day i ($^{\circ}\text{C}$)
$T_{\min.}$	=	Daily minimum temperature of day i ($^{\circ}\text{C}$)
T_b	=	Base temperature

In present study, the base temperature of linseed was taken as 4.4°C .

3.3.2 Hydro thermal units

The hydrothermal unit was calculated by multiplying GDD with relative humidity at critical growth stages of crop.

Hydrothermal units = GDD x Relative humidity

3.3.3 Photo thermal units

The photo thermal units were calculated by multiplying GDD with day length at critical stages of crop.

$$\text{Photothermal units} = \text{GDD} \times \text{Day length}$$

3.3.4 Light use efficiency and light interception through crop canopy

During photosynthesis, plants use energy in the region of electromagnetic spectrum from 400-700 nm. The radiation in this range, referred to as PAR (Photosynthetically Active Radiation) was measured in energy units of quanta (photons) per unit time per unit surface area.

The PAR is measured by an instrument Line Quantum Sensor for measuring transmitted radiation. The sensor was in the crop while for measuring incident radiation Line Quantum Sensor was kept on open area. Both incident and transmitted radiations were measured at the time to reduce the time variation.

3.3.4.1 Measurement of incident radiations (PAR)

For measurement of incoming PAR, Line Quantum Sensor was positioned facing up 1ft. above the top of the canopy and value was recorded for incoming PAR.

3.3.4.2 Measurement of reflected radiations

For measurement of reflected radiations, Line Quantum Sensor was positioned facing down towards the bed and value was recorded for reflected.

3.3.4.3 Measurement of transmitted radiations

Line Quantum sensor was placed above the ground across the rows and value was recorded for transmitted radiations.

- a. Reflected PAR by canopy + Soil = RPARC

$$\text{RPARC \%} = \text{RPARC} / \text{PARO} \times 100$$

- b. Reflected PAR by soil = PAARS

$$\text{RPARS \%} = \text{RPARS} / \text{PARO} \times 100$$



Plate.2. Line quantum sensor and data logger to measure incoming radiation

- c. Reflected PAR by canopy = RPAR

$$\text{RPAR} = \text{RPARC} - \text{RPFERS}$$

3.3.4.4 Measurement of absorbed radiations

- a. $\text{APAR} = (\text{PAR} + \text{RPAR}) - (\text{TPAR} + \text{RPAR})$
 b. Intercepted PAR = Incident PAR – Transmitted PAR
 c. $\text{IPAR} = \text{PARO} - \text{TPAR} \mu \text{ mol m}^{-2} \text{ s}^{-1}$

3.5 Details of instruments

3.5.1 LI-191 SA Line Quantum Sensor

The LI-191 sensor is designed for measuring PAR (Photo synthetically Active Radiation) in applications where the radiation is to be measured in spatially non-uniform canopies (such as within canopies). To achieve this, the sensor features a sensing area that is one meter in length (Plate 1). The LI-191 SA has quantum (photon) response through the wave length range of 400 to 700 nm for PPED (Photosynthetic Photon Flux Density) as generally preferred for PAR measurements, and has an output in units of mole.

Where,

$$1 \mu \text{ mol m}^{-2} \text{ s}^{-1} = 1 \mu \text{E m}^{-2} \text{ s}^{-1} = 6.02 \times 10^{17} \text{ photon m}^{-2} \text{ s}^{-1}$$

The LI-191 SA Line Quantum sensor, which spatially averages radiation over its one meter length, minimize the errors and allows one to easily make many measurements in a short period of time. The sensor was connected to the LI-191 data logger.

Since the sensing area is a flat acrylic diffuser, the response of given angle of incidence is fairly constant, as the azimuth angle around the sensor is varied. It is specified at less than ... at a 45° angle of elevation for 360° sensor rotation.

3.5.2 LI-1000 Data Logger

The LI-1000 Data Logger is a 10 channel data logger that functions both as a data logging device and a multichannel, auto ranging

meter. The electronics of the LI-1000 have been optimized for highly accurate measurement of LI-1000 radiation sensors, which have a current signal. The LI-1000 is also well suited to measure low impedance voltage sensors such as thermocouples and sensors with a pulsed output (tipping bucket rain gauges, etc., Plate 2). A wide variety of other sensors for environmental and industrial test and measurement can also be measured with the LI-1000.

Theory of operation

For measurement of radiation by Line Quantum Sensor following commands are given

I	ON	V	Multiplier (-107.99)
II	INST MODI	VI	Label-UM
III	CH 1	VII	Ave. 1 minute
IV	Range A		

3.6 Statistical analysis and interpretation of data

Standard method of “Analysis of variance” was used for analyzing the data (Panse and Sukhatme, 1985). Standard error of the means (SEm) was worked out for each factor and interactions. Wherever the results were significant, the critical difference (C.D.) was worked out at 5 per cent level of significance. The data were suitably illustrated with graphs and figures at appropriate places.

4. RESULT AND DISCUSSION

A field experiment entitled “ Effect of weather parameters on linseed (*Linum usitatissimum* L.) varieties under extended sowing times” was carried out during *rabi*, 2013 at Agricultural Meteorology Department Farm, College of Agriculture, Pune-5. The detail results of investigation are presented and discussed in this chapter.

4.1 Plant count

4.1.1 Initial plant count

The data regarding the mean plant count at 14 days after sowing per hectare are presented in Table 8.

Data in Table 6 revealed that the mean initial plant count per hectare was found 6.55 lakh ha⁻¹. The effects of varieties, sowing times and their interactions did not differ significantly the plant population at 14 days after sowing.

4.1.2 Final plant count

The data regarding the mean plant count at harvest per hectare was found 6.53 lakh ha⁻¹. The effects of varieties, sowing times and their interactions did not affect significantly the plant count at harvest (Table 8).

4.2 Growth studies

The biometric observations of linseed were recorded on various growth characters viz., plant height, number of branches per plant, plant spread, number of capsules per plant, days to 50% flowering, days to maturity and dry matter per plant at regular interval of 14 ,28, 42, 56, 70, 84 days after sowing and at harvest, respectively.

Table 8: Mean initial and final plant population (lakh/ha) as influenced by different treatments

Treatment	Plant population (lakh/ha)	
	Initial	Final
A. Varieties (V)		
V ₁ : PKVNL-260	6.55	6.53
V ₂ : NL-97	6.55	6.53
V ₃ : Padmini	6.55	6.53
S.E. m $\pm$	0.001	0.001
C.D. at 5%	NS	NS
B. Sowing times (S)		
S ₁ : 44 MW	6.55	6.53
S ₂ : 45 MW	6.56	6.54
S ₃ : 46 MW	6.55	6.53
S ₄ : 47 MW	6.55	6.53
S ₅ : 48 MW	6.55	6.53
S.E. m $\pm$	0.003	0.003
C.D. at 5%	NS	NS
C. Interaction (V x S)		
S.E. m $\pm$	0.002	0.002
C.D. at 5%	NS	NS
General mean	6.55	6.53

4.2.1 Plant height (cm)

The data in respect of mean periodical plant height of linseed as influenced by different treatments are presented in Table 9 and graphically depicted in Fig.3.

From the data in Table 9, it was observed that the mean plant height increased with advancement in the age of the crop till harvest. The mean initial plant height was 11.18 cm at 14 days and increased up to 55.52 cm at 84 days after sowing. However, it was slightly reduced at harvest which was 53.93 cm. The reduced plant height at harvest might be because after maturity the plant shrinks and reduced their plant height.

Effect of varieties

The mean plant height was significantly influenced up to 84 days after sowing due to different varieties (Table 9).

The maximum plant height was observed at 84 days after sowing with PKVNL-260 (59.58 cm) over rest of the varieties. Thus, the period of grand growth was observed between 42 to 70 days.

This might be due to genetical characters of PKVNL-260. The similar findings were reported by ([http:// www.ijcm.as.com](http://www.ijcm.as.com)).

Effect of sowing times

The mean plant height was significantly influenced by different sowing times. The *rabi* linseed sown during 45th MW has recorded maximum plant height at 84 days after sowing (56.31 cm).

This might be due to congenial climatic condition for better germination and further growth and development of *rabi* linseed crop.

Among the sowing times, linseed sown during 45th MW attained maximum plant height (56.31 cm). Similar results were reported by Yadav *et al* (2002) and Tomar and Mishra (1991).

Table 9: Mean plant height (cm) as influenced periodically by different treatments

Treatment	Days after sowing (DAS)						
	14	28	42	56	70	84	At harvest
A. Varieties (V)							
V ₁ : PKVNL-260	11.77	18.56	34.02	49.42	56.65	59.58	58.18
V ₂ : NL-97	10.67	17.51	32.86	47.42	50.04	52.52	50.76
V ₃ : Padmini	11.10	17.97	33.34	48.30	52.89	54.43	52.84
S.E. m $\pm$	0.013	0.021	0.072	0.076	0.099	0.008	0.02
C.D. at 5%	0.053	0.086	0.288	0.308	0.4	0.033	0.081
B. Sowing times (S)							
S ₁ : 44 MW	11.17	18.47	34.35	48.87	53.46	55.85	54.40
S ₂ : 45 MW	12.02	19.23	35.01	49.73	54.57	56.31	54.90
S ₃ : 46 MW	11.16	18.19	34.34	48.73	53.46	55.84	54.38
S ₄ : 47 MW	11.16	18.17	33.34	48.70	53.28	55.47	53.98
S ₅ : 48 MW	10.40	16.01	30.00	45.87	51.19	54.10	51.97
S.E. m $\pm$	0.029	0.025	0.066	0.101	0.077	0.012	0.029
C.D. at 5%	0.084	0.074	0.192	0.296	0.227	0.036	0.084
C. Interaction (V x S)							
S.E. m $\pm$	0.029	0.048	0.16	0.171	0.222	0.018	0.045
C.D. at 5%	0.014	0.139	0.375	NS	0.453	0.066	0.155
General mean	11.18	18.02	33.41	48.36	53.19	55.52	53.93

Table 10 .Mean plant height (cm) as influenced periodically by interaction between varieties and sowing times

Sowing time Varieties	14 DAS						28 DAS					
	Sowing times						Sowing times					
	S ₁ (44MW)	S ₂ (45MW)	S ₃ (46MW)	S ₄ (47MW)	S ₅ (48MW)	Mean	S ₁ (44MW)	S ₂ (45MW)	S ₃ (46MW)	S ₄ (47MW)	S ₅ (48MW)	Mean
V ₁ : PKVNL-260	11.71	12.69	11.73	11.68	11.08	11.77	19.01	19.68	18.63	19.12	16.38	18.57
V ₂ : NL-97	10.78	11.48	10.67	10.57	9.87	10.67	18.00	18.61	17.84	17.55	15.57	17.51
V ₃ : Padmini	11.04	11.88	11.08	11.22	10.27	11.10	18.41	19.42	18.10	17.85	16.08	17.97
Mean	11.18	12.02	11.16	11.16	10.40	11.18	18.47	19.24	18.19	18.17	16.01	18.02
S.E. m ±	0.029						0.048					
C.D. at 5%	0.0149						0.139					

Table .10 . Continued..[Mean plant height (cm)]

Sowing time Varieties	42 DAS						56 DAS					
	Sowing times						Sowing times					
	S ₁ (44MW)	S ₂ (45MW)	S ₃ (46MW)	S ₄ (47MW)	S ₅ (48MW)	Mean	S ₁ (44MW)	S ₂ (45MW)	S ₃ (46MW)	S ₄ (47MW)	S ₅ (48MW)	Mean
V ₁ : PKVNL-260	35.01	35.37	34.75	34.83	30.14	34.02	56.68	58.52	57.88	56.68	53.49	56.65
V ₂ : NL-97	33.67	34.53	34.13	32.16	29.84	32.87	50.10	50.50	49.90	50.30	49.40	50.04
V ₃ : Padmini	34.37	35.13	34.15	33.03	30.04	33.35	53.61	54.69	52.60	52.86	50.69	52.89
Mean	34.35	35.01	34.35	33.34	30.01	33.41	53.46	54.57	53.46	53.28	51.19	53.19
S.E. m ±	0.16						0.222					
C.D. at 5%	0.375						0.453					

Table 10 . Continued. [Mean plant height (cm)]

Sowing time Varieties	84 DAS						At harvest					
	Sowing times						Sowing times					
	S ₁ (44MW)	S ₂ (45MW)	S ₃ (46MW)	S ₄ (47MW)	S ₅ (48MW)	Mean	S ₁ (44MW)	S ₂ (45MW)	S ₃ (46MW)	S ₄ (47MW)	S ₅ (48MW)	Mean
V₁: PKVNL-260	60.47	61.44	60.54	59.64	55.83	59.58	59.04	60.04	59.06	58.15	54.62	58.18
V₂ : NL-97	52.54	52.63	52.38	52.23	52.83	52.52	51.02	51.23	50.94	50.74	49.89	50.76
V₃ : Padmini	54.53	54.85	54.60	54.53	54.63	54.43	53.13	53.43	53.15	53.05	51.42	52.84
Mean	55.88	56.31	55.84	55.47	54.10	55.51	54.40	54.90	54.38	53.98	51.97	53.93
S.E. m ±	0.018						0.045					
C.D. at 5%	0.066						0.155					

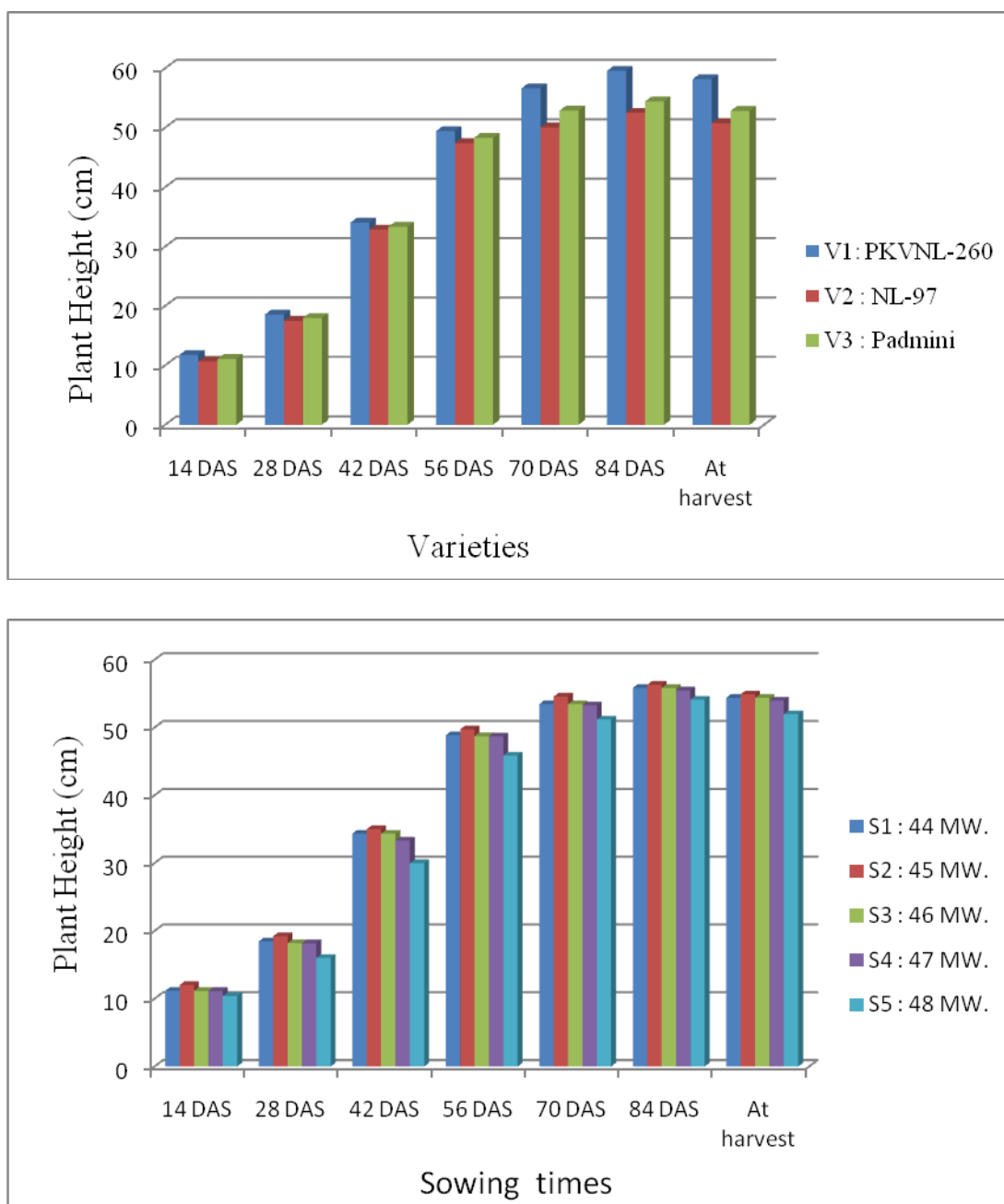


Fig.3. Mean plant height (cm) as influenced periodically by varieties and sowing times

Effect of interaction

The interaction between varieties and sowing time at all the growth stages were found significant except 56 DAS. The relevant data are presented in Table 8.

The variety PKVNL-260 when sown during 45th MW recorded the highest plant height at 14 DAS (11.77 cm), 28 DAS (18.56 cm), 42 DAS (34.02 cm), 56 DAS (49.42) , 70 DAS (56.65 cm) and at 84 DAS (59.58 cm). At harvest, the plant height was slightly decreased due to drying of tip. A variety PKVNL-260 recorded maximum plant height due to varietal characters and weather conditions at that period.

4.2.2 Mean plant Spread

The data on mean plant spread plant⁻¹ as influenced periodically by different treatments are presented in Table 11 and graphically depicted in Fig. 5.

It could revealed that the plant spread increased from 2.15 at 14 days to 13.92 at 84 days after sowing. However, it was reduced at harvest due to senescence.

Effect of varieties

The difference in the mean plant spread due to varieties was significant at all the crop growth stages (Table 11). The highest plant spread (14.11) recorded with PKVNL-260 at 84 days after sowing ((Table 11) and drastically reduced at harvest due to senescence of leaves. The next varieties in order of sequence were Padmini and NL-97. The similar findings were reported by ([http:// www.ijcm.as.com](http://www.ijcm.as.com)).

Effect of sowing times

The mean plant spread were increased as per advancement in age of crop till 84 DAS for all the sowing times. The mean plant spread plant⁻¹ was significantly influenced by different sowing times. The *rabi*

linseed sown during 45th MW produced maximum plant spread at 84 days after sowing (15.09). The next sowing times in order of sequence were 44th, 46th, 47th MW and 48th MW sowing.

This might be due to increase in interception of radiation in *rabi* season which increased the rate of photosynthesis and assimilation of organic constituents, which may utilized for induction of leaves in linseed. Similar results were reported by Tomar and Mishra (1991).

Effect of interaction

The interaction between varieties and sowing times at all the growth stages and at harvest were significant and relevant data are presented in Table 12.

The variety PKVNL-260 when sown during 45th MW recorded higher plant spread at 84 days after sowing. This might be due to varietal performance to interaction of radiation during *rabi*. The mean plant spread were increased with advancement in the age of crop till 84 DAS. The next sowing times in order of sequence were 44th, 46th, 47th and 48th MW sowing.

Table 11: Mean plant spread (cm) as influenced periodically by different treatments

Treatment	Days after sowing (DAS)						
	14	28	42	56	70	84	At harvest
A. Varieties (V)							
V ₁ : PKVNL-260	2.31	5.25	8.34	11.36	13.07	14.11	12.92
V ₂ : NL-97	2.07	5.08	8.02	10.94	12.76	13.82	12.72
V ₃ : Padmini	2.08	5.08	8.03	10.95	12.77	13.83	12.73
S.E. m $\pm$	0.018	0.01	0.012	0.042	0.029	0.009	0.021
C.D. at 5%	0.074	0.04	0.048	0.169	0.116	0.038	0.083
B. Sowing times (S)							
S ₁ : 44 MW	2.22	5.32	8.29	11.43	13.11	14.14	13.0
S ₂ : 45 MW	2.40	5.51	8.50	11.74	14.09	15.09	13.93
S ₃ : 46 MW	2.19	2.29	8.23	11.36	12.96	13.96	12.78
S ₄ : 47 MW	2.16	4.90	8.04	11.03	12.53	13.61	12.49
S ₅ : 48 MW	1.80	4.67	7.60	9.86	11.64	12.80	11.76
S.E. m $\pm$	0.019	0.012	0.028	0.048	0.023	0.021	0.025
C.D. at 5%	0.056	0.036	0.083	0.142	0.067	0.63	0.074
C. Interaction (V x S)							
S.E. m $\pm$	0.041	0.022	0.027	0.094	0.064	0.021	0.046
C.D. at 5%	0.107	0.067	0.147	0.268	0.132	0.111	0.138
General mean	2.15	5.14	8.13	11.08	12.87	13.92	12.79

Table 12 . Mean plant spread (cm) as influenced periodically by interaction between varieties and sowing times

Sowing time Varieties	14 DAS						28 DAS					
	Sowing times						Sowing times					
	S ₁ (44MW)	S ₂ (45MW)	S ₃ (46MW)	S ₄ (47MW)	S ₅ (48MW)	Mean	S ₁ (44MW)	S ₂ (45MW)	S ₃ (46MW)	S ₄ (47MW)	S ₅ (48MW)	Mean
V₁: PKVNL-260	2.40	2.56	2.40	2.36	1.46	2.24	3.70	4.20	3.66	3.66	2.60	3.56
V₂: NL-97	1.43	1.50	1.23	1.23	0.33	1.14	2.34	2.56	2.16	2.16	1.50	2.16
V₃: Padmini	2.20	2.26	1.36	1.23	1.03	1.62	3.63	3.66	2.33	2.16	1.80	2.72
Mean	2.01	2.11	1.66	1.61	0.94	1.66	3.24	3.47	2.72	2.66	1.96	2.81
S.E. m ±	0.041						0.022					
C.D. at 5%	0.107						0.067					

Table 12 . Continued..[Mean plant spread (cm)]

Sowing time Varieties	42 DAS						56 DAS					
	Sowing times						Sowing times					
	S ₁ (44MW)	S ₂ (45MW)	S ₃ (46MW)	S ₄ (47MW)	S ₅ (48MW)	Mean	S ₁ (44MW)	S ₂ (45MW)	S ₃ (46MW)	S ₄ (47MW)	S ₅ (48MW)	Mean
V₁: PKVNL-260	8.53	8.93	8.40	8.16	7.66	8.34	11.30	12.16	11.90	11.06	10.36	11.36
V₂: NL-97	8.13	8.23	8.08	7.93	7.50	7.97	11.33	11.36	11.06	10.86	9.46	10.81
V₃: Padmini	8.16	8.33	8.23	8.03	7.63	8.07	11.66	11.70	11.10	11.16	9.73	11.07
Mean	8.27	8.50	8.23	8.04	7.60	8.13	11.43	11.74	11.35	11.03	9.85	11.08
S.E. m ±	0.027						0.094					
C.D. at 5%	0.147						0.268					

Table 12 . Continued.. [Mean plant spread (cm)]

Sowing time Varieties	70 DAS						84 DAS					
	Sowing times						Sowing times					
	S ₁ (44MW)	S ₂ (45MW)	S ₃ (46MW)	S ₄ (47MW)	S ₅ (48MW)	Mean	S ₁ (44MW)	S ₂ (45MW)	S ₃ (46MW)	S ₄ (47MW)	S ₅ (48MW)	Mean
V ₁ : PKVNL-260	13.20	14.26	14.86	12.70	12.10	13.42	14.16	15.40	14.13	13.86	13.00	14.11
V ₂ : NL-97	12.96	13.86	12.90	12.40	11.26	12.68	14.13	14.83	13.76	13.36	12.56	13.73
V ₃ : Padmini	13.16	14.13	13.10	12.50	11.56	12.89	14.13	15.03	13.96	13.60	12.83	13.91
Mean	13.11	14.08	13.62	12.53	11.64	13.00	14.14	15.08	13.95	13.61	12.80	13.92
S.E. m ±	0.064						0.021					
C.D. at 5%	0.132						0.111					

Table 12 . Continued.. [Mean plant spread (cm)]

Sowing time Varieties	At harvest					
	Sowing times					
	S ₁ (44MW)	S ₂ (45MW)	S ₃ (46MW)	S ₄ (47MW)	S ₅ (48MW)	Mean
V ₁ :PKVNL-260	13.06	14.06	12.93	12.70	11.93	12.94
V ₂ : NL-97	12.93	13.76	12.60	12.26	11.50	12.61
V ₃ : Padmini	13.00	13.90	12.80	12.50	11.90	12.82
Mean	13.00	13.91	12.77	12.48	11.77	12.79
S.E. m ±	0.046					
C.D. at 5%	0.138					

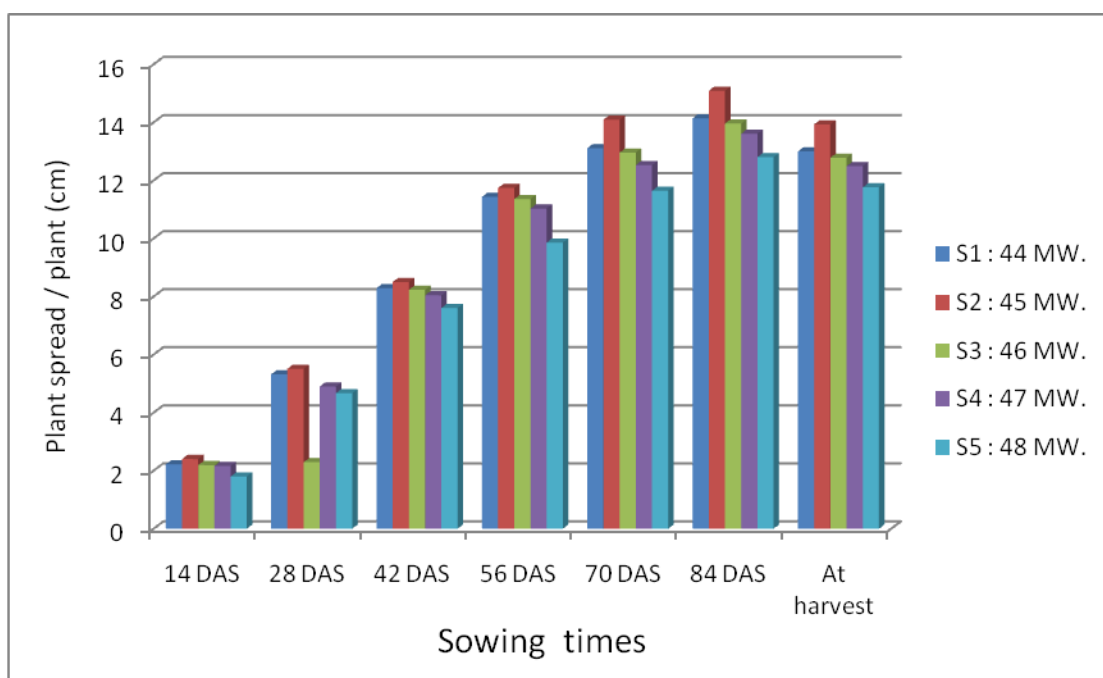
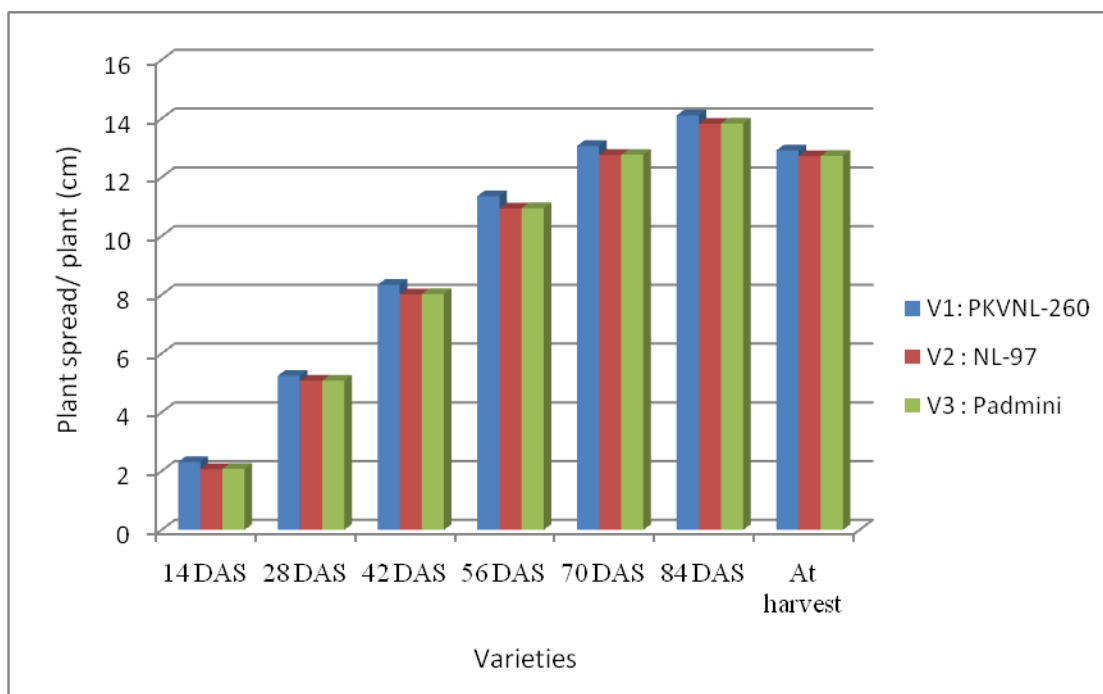


Fig.5. Mean plant spread per plant (cm) as influenced periodically by varieties and sowing times



PKVNL-260

NL-97

Padmini

Plate. 3.General view of linseed crop varieties

4.2.3 Mean number of branches per plant

The data on mean number of branches per plant as influenced periodically by various treatments are presented in Table 13 and depicted in Fig. 4. It would revealed that the number of branches increased from 1.67 at 14 days to 7.7 at harvest of crop.

Effect of varieties

The differences in the mean number of branches per plant due to varieties were significant at all the crop growth stages. The higher number of branches plant⁻¹ produced with PKVNL-260 variety (8.97) over rest of the varieties (Table 13). The next varieties in order of sequence were Padmini and NL-97.

The similar findings were reported by ([http:// www.ijcm.as.com](http://www.ijcm.as.com)), Varma *et al* (2005).

Effect of sowing time

Sowing of linseed at 45th MW produced maximum number of branches plant⁻¹ (8.16) and revealed that the number of branches was significantly affected due to different sowing times. The next sowing times in order of sequence were 44th, 46th, 47th and 48th MW sowings. Yadav *et al* (2002) and Tomar and Mishra(1991).

Effect of interaction

The interaction between varieties and sowing times were significant for mean number of branches per plant at all the growth stages (Table 14).

The variety PKVNL-260 when sown during 45th MW recorded higher number of branches per plant at harvest. This might be due to varietal performance to interaction of radiation during *rabi*. The mean number of branches per plant were increased with advancement in the age of crop till at harvest. The next sowing times in order of sequence were 44th, 46th, 47th and 48th MW sowing.

Table 13: Mean number of branches per plant as influenced periodically by different treatments

Treatment	Days after sowing (DAS)						
	14	28	42	56	70	84	At harvest
A. Varieties (V)							
V ₁ : PKVNL-260	2.24	3.57	6.57	7.74	8.80	8.89	8.97
V ₂ : NL-97	1.15	2.16	4.14	5.36	6.69	6.75	6.81
V ₃ : Padmini	1.62	2.72	4.91	6.03	7.21	7.32	7.67
S.E. m $\pm$	0.045	0.03	0.033	0.016	0.022	0.016	0.018
C.D. at 5%	0.182	0.123	0.133	0.063	0.09	0.063	0.07
B. Sowing times (S)							
S ₁ : 44 MW	2.01	3.24	5.47	6.72	7.73	7.81	7.89
S ₂ : 45 MW	2.11	3.48	6.11	6.99	7.99	8.07	8.16
S ₃ : 46 MW	1.67	2.72	5.46	6.41	7.66	7.73	7.79
S ₄ : 47 MW	1.61	2.67	5.09	6.28	7.51	7.58	7.63
S ₅ : 48 MW	0.94	1.97	3.92	5.48	6.93	7.00	7.03
S.E. m $\pm$	0.043	0.02	0.028	0.009	0.012	0.008	0.014
C.D. at 5%	0.125	0.057	0.083	0.027	0.034	0.023	0.04
C. Interaction (V x S)							
S.E. m $\pm$	0.101	0.068	0.074	0.035	0.05	0.035	0.041
C.D. at 5%	0.242	0.118	0.163	0.057	0.073	0.049	0.08
General mean	1.67	2.82	5.21	6.38	7.56	7.64	7.70

Table 14 . Mean no. of branches/plant as influenced periodically by interaction between varieties and sowing times

Sowing time Varieties	14 DAS						28 DAS					
	Sowing times						Sowing times					
	S ₁ (44MW)	S ₂ (45MW)	S ₃ (46MW)	S ₄ (47MW)	S ₅ (48MW)	Mean	S ₁ (44MW)	S ₂ (45MW)	S ₃ (46MW)	S ₄ (47MW)	S ₅ (48MW)	Mean
V₁: PKVNL-260	2.40	2.56	2.40	2.36	1.46	2.24	3.70	4.20	3.66	3.66	2.60	3.56
V₂ : NL-97	1.43	1.50	1.23	1.23	0.33	1.14	2.34	2.56	2.16	2.16	1.50	2.16
V₃ : Padmini	2.20	2.26	1.36	1.23	1.03	1.62	3.63	3.66	2.33	2.16	1.80	2.72
Mean	2.01	2.11	1.66	1.61	0.94	1.66	3.24	3.47	2.72	2.66	1.96	2.81
S.E. m ±	0.101						0.068					
C.D. at 5%	0.242						0.118					

Table 14 . Continued..[Mean no. of branches/plant]

Sowing time Varieties	42 DAS						56 DAS					
	Sowing times						Sowing times					
	S ₁ (44MW)	S ₂ (45MW)	S ₃ (46MW)	S ₄ (47MW)	S ₅ (48MW)	Mean	S ₁ (44MW)	S ₂ (45MW)	S ₃ (46MW)	S ₄ (47MW)	S ₅ (48MW)	Mean
V₁: PKVNL-260	7.20	7.30	7.03	6.86	4.46	6.57	8.16	8.46	8.16	7.86	6.03	7.74
V₂ : NL-97	4.11	5.36	3.86	4.13	3.26	4.14	5.63	5.93	5.23	5.13	4.86	5.36
V₃ : Padmini	5.10	5.66	5.46	4.26	4.03	4.90	6.36	6.56	5.83	5.83	5.53	6.02
Mean	5.47	6.11	5.45	5.08	3.92	5.20	6.72	6.98	6.41	6.27	5.47	6.37
S.E. m ±	0.074						0.035					
C.D. at 5%	0.163						0.057					

Table 14 . Continued.. [Mean no. of branches/plant]

Sowing time Varieties	70 DAS						84 DAS					
	Sowing times						Sowing times					
	S ₁ (44MW)	S ₂ (45MW)	S ₃ (46MW)	S ₄ (47MW)	S ₅ (48MW)	Mean	S ₁ (44MW)	S ₂ (45MW)	S ₃ (46MW)	S ₄ (47MW)	S ₅ (48MW)	Mean
V ₁ : PKVNL-260	9.20	9.50	9.10	8.80	7.40	8.80	9.30	9.60	9.20	8.90	7.46	8.89
V ₂ : NL-97	6.70	7.06	6.66	6.60	6.40	6.68	6.76	7.13	7.73	6.66	6.46	6.75
V ₃ : Padmini	7.30	7.40	7.20	7.13	7.00	7.20	7.36	7.46	7.26	7.16	7.06	7.26
Mean	7.73	7.98	7.65	7.51	6.93	7.56	7.81	8.06	7.73	7.57	7.00	7.63
S.E. m ±	0.05						0.035					
C.D. at 5%	0.073						0.049					

Table 14 . Continued.. [Mean no. of branches/plant]

Sowing time Varieties	At harvest					
	Sowing times					
	S ₁ (44MW)	S ₂ (45MW)	S ₃ (46MW)	S ₄ (47MW)	S ₅ (48MW)	Mean
V ₁ : PKVNL-260	9.40	9.70	9.26	8.96	7.50	8.96
V ₂ : NL-97	6.83	7.23	6.80	6.70	6.50	6.81
V ₃ : Padmini	7.43	7.53	7.30	7.23	7.10	7.32
Mean	7.88	8.15	7.78	7.63	7.03	7.69
S.E. m ±	0.041					
C.D. at 5%	0.08					

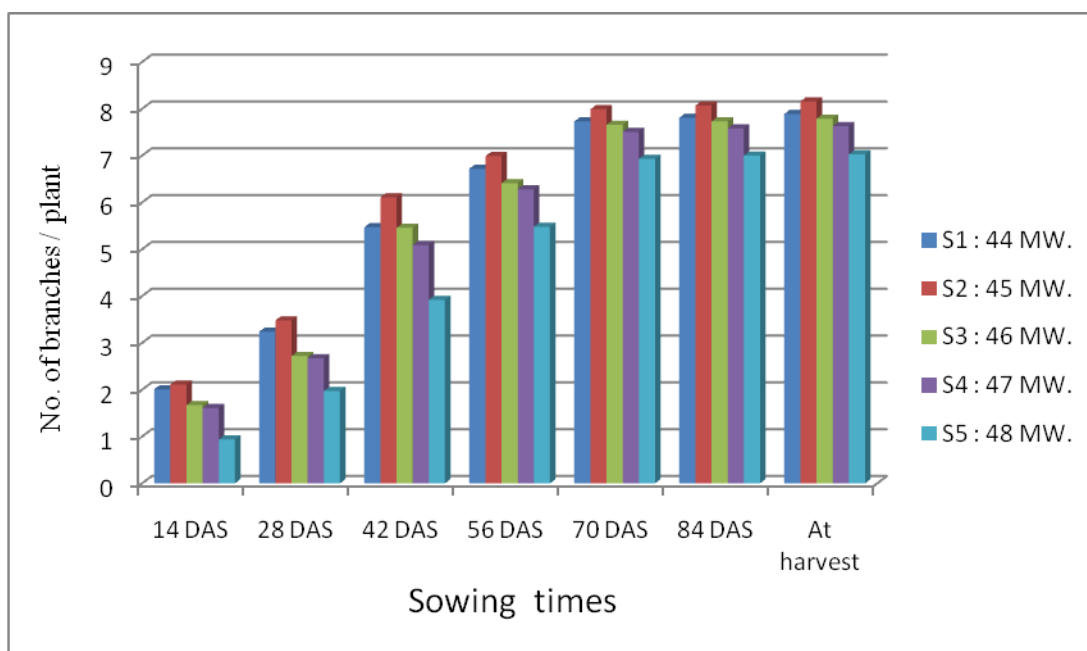
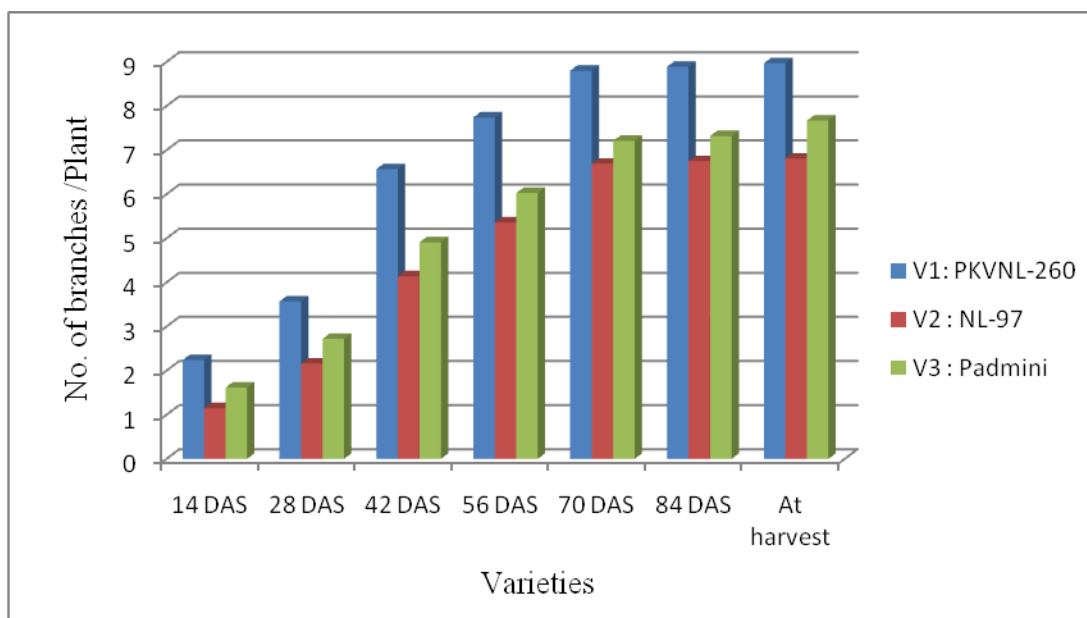


Fig.4. Mean number of branches per plant as influenced periodically by varieties and sowing times

4.2.4 Mean dry matter (g)

The data on mean total dry matter per plant as affected periodically by various treatments are presented in Table 15 and depicted in Fig. 6. It would revealed that the total dry matter increased from 0.06 (g) at 14 days to 6.48 (g) at harvest of crop.

Effect of varieties

The differences in the mean total dry matter per plant due to varieties were significant at all the crop growth stages. The higher dry matter produced with PKVNL-260 variety (6.53 g) over rest of the varieties (Table 15). The next varieties in order of sequence were Padmini and NL-97. Similar results reported by Verma *et al* (2005).

Effect of sowing time

Sowing of linseed at 45th MW produced maximum dry matter (6.72 g) and revealed that the total dry matter was significantly affected due to different sowing times. The next sowing times in order of sequence were 44th, 46th, 47th and 48th MW sowings. Similar results reported by Mathur *et al* (1984), Verma *et al* (2005).

Effect of interaction

The interaction between varieties and sowing times were significant for mean total dry matter per plant at all the growth stages except 42 DAS. (Table 16).

The variety PKVNL-260 when sown during 45th MW recorded higher total dry matter per plant at harvest. The mean total dry matter per plant were increased with advancement in the age of crop till harvest. The next sowing times in order of sequence were 44th, 46th, 47th and 48th MW sowing.

Table15 : Mean total dry matter (g) as influenced periodically by different treatments

Treatment	Days after sowing (DAS)						
	14	28	42	56	70	84	At harvest
A. Varieties (V)							
V ₁ : PKVNL-260	0.064	1.22	2.03	3.11	4.91	5.85	6.53
V ₂ : NL-97	0.059	1.15	1.98	3.00	4.74	5.66	6.43
V ₃ : Padmini	0.061	1.18	2.00	3.02	4.83	5.79	6.49
S.E. m $\pm$	0	0.002	0.007	0.001	0.001	0.003	0.002
C.D. at 5%	0.002	0.009	0.027	0.006	0.004	0.007	0.009
B. Sowing times (S)							
S ₁ : 44 MW	0.063	1.21	2.01	3.02	4.96	5.94	6.55
S ₂ : 45 MW	0.064	1.26	2.09	3.24	5.08	5.98	6.72
S ₃ : 46 MW	0.06	1.18	2.00	3.00	4.88	5.83	6.50
S ₄ : 47 MW	0.06	1.16	1.98	2.99	4.68	5.67	6.35
S ₅ : 48 MW	0.059	1.11	1.96	2.97	4.52	5.40	6.30
S.E. m $\pm$	0.001	0.003	0.012	0.001	0.001	0.007	0.001
C.D. at 5%	0.002	0.008	0.034	0.002	0.004	0.021	0.004
C. Interaction (V x S)							
S.E. m $\pm$	0.001	0.005	0.015	0.003	0.002	0.007	0.005
C.D. at 5%	0.004	0.015	NS	0.003	0.008	0.037	0.008
General mean	0.06	1.18	2.00	3.04	4.82	5.78	6.48

Table 16. Mean total dry matter per plant (g) as influenced periodically by interaction between varieties and sowing times

Sowing time Varieties	14 DAS						28 DAS					
	Sowing times						Sowing times					
	S ₁ (44MW)	S ₂ (45MW)	S ₃ (46MW)	S ₄ (47MW)	S ₅ (48MW)	Mean	S ₁ (44MW)	S ₂ (45MW)	S ₃ (46MW)	S ₄ (47MW)	S ₅ (48MW)	Mean
V₁: PKVNL-260	0.07	0.07	0.06	0.06	0.06	0.06	1.25	1.32	1.20	1.18	1.12	1.21
V₂: NL-97	0.06	0.06	0.06	0.06	0.05	0.05	1.18	1.21	1.15	1.13	1.08	1.15
V₃: Padmini	0.06	0.06	0.06	0.06	0.06	0.06	1.20	1.24	1.18	1.16	1.11	1.18
Mean	0.06	0.06	0.06	0.06	0.05	0.056	1.21	1.25	1.18	1.16	1.10	1.18
S.E. m ±	0.001						0.005					
C.D. at 5%	0.004						0.015					

Table 16 .Continued..[Mean total dry matter per plant (g)]

Sowing time Varieties	56 DAS						70 DAS					
	Sowing times						Sowing times					
	S ₁ (44MW)	S ₂ (45MW)	S ₃ (46MW)	S ₄ (47MW)	S ₅ (48MW)	Mean	S ₁ (44MW)	S ₂ (45MW)	S ₃ (46MW)	S ₄ (47MW)	S ₅ (48MW)	Mean
V₁: PKVNL-260	3.03	3.51	3.02	3.00	2.99	3.11	5.00	5.21	4.91	4.81	4.61	4.91
V₂: NL-97	3.00	3.11	2.99	2.98	2.95	3.00	4.91	5.00	4.81	4.51	4.41	4.73
V₃: Padmini	3.02	3.11	3.00	2.99	2.97	3.01	4.96	5.02	4.91	4.71	4.51	4.82
Mean	3.01	3.24	3.00	2.99	2.97	3.04	4.63	5.08	4.88	4.68	4.51	4.82
S.E. m ±	0.003						0.002					
C.D. at 5%	0.003						0.008					

Table 16 .Continued.. [Mean total dry matter per plant (g)]

Sowing time Varieties	84 DAS						At harvest					
	Sowing times						Sowing times					
	S ₁ (44MW)	S ₂ (45MW)	S ₃ (46MW)	S ₄ (47MW)	S ₅ (48MW)	Mean	S ₁ (44MW)	S ₂ (45MW)	S ₃ (46MW)	S ₄ (47MW)	S ₅ (48MW)	Mean
V₁: PKVNL-260	6.00	6.03	5.90	5.80	5.50	5.84	6.61	6.82	6.52	6.37	6.32	6.53
V₂ : NL-97	5.90	5.90	5.70	5.50	5.30	5.66	6.47	6.60	6.46	6.31	6.27	6.42
V₃ : Padmini	5.93	6.00	5.90	5.70	5.40	5.78	6.57	6.73	6.50	6.36	6.30	6.49
Mean	5.94	5.97	5.83	5.66	5.40	5.76	6.55	6.71	6.49	6.35	6.30	6.48
S.E. m ±	0.007						0.005					
C.D. at 5%	0.037						0.008					

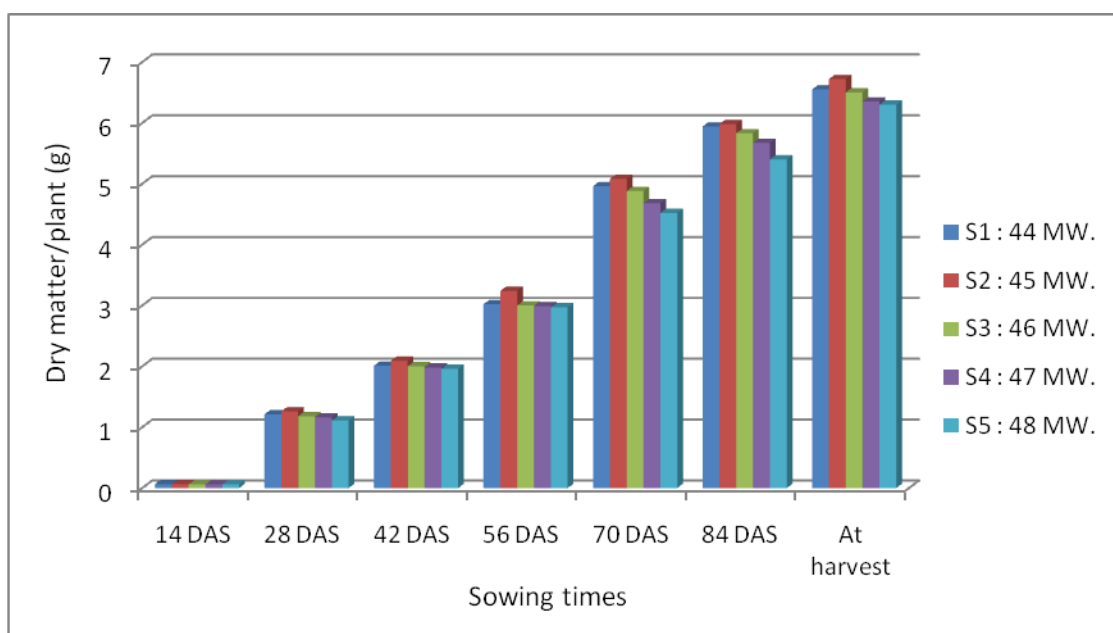
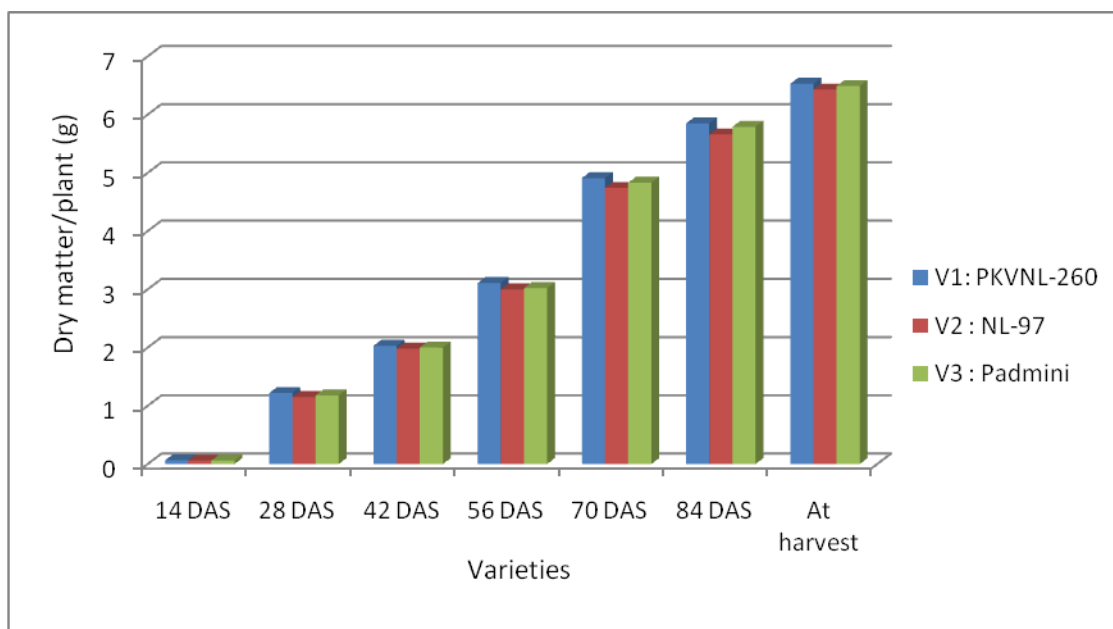


Fig.6. Mean dry matter per plant (g) as influenced periodically by varieties and sowing times



Sowing time-44th MW

45th MW

46th MW

Plate .4.View of flowering stage in linseed at extended sowing time

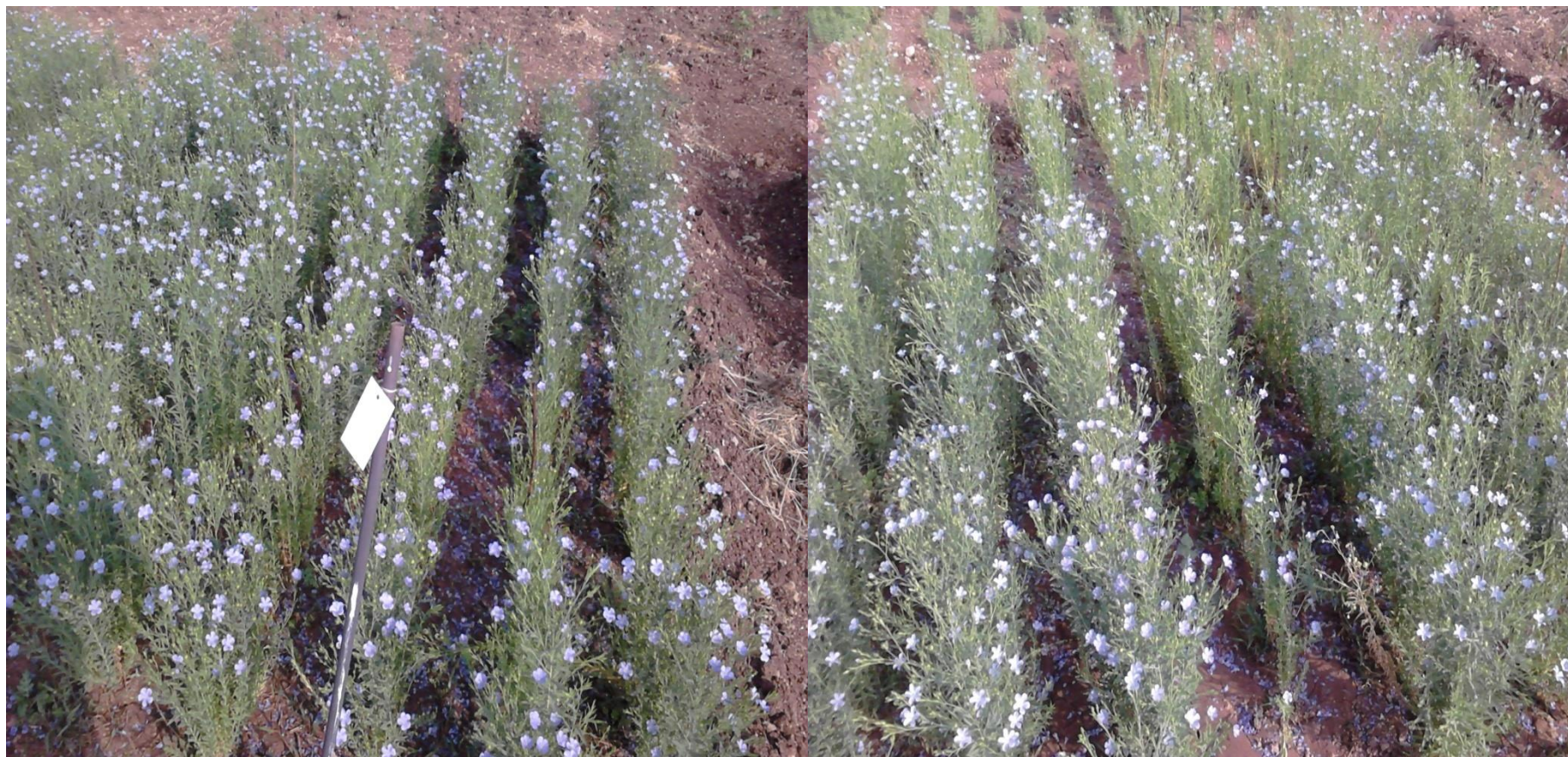
47th MW48th MW

Plate .5. View of flowering stage in linseed at extended sowing time

4.2.5 Days to 50% flowering

The data pertaining to days to 50% flowering as influenced by different treatments are presented in Table 15 and depicted in Fig.7 . The days to 50% flowering was significantly influenced due to varieties and sowing times.

The data presented in Table 15 revealed that the mean days to 50% flowering was 58.11.

Effect of varieties

The data presented in Table 15 revealed that days to 50% flowering were significantly influenced due to varieties. A variety NL-97 recorded minimum days to 50% flowering (55.80) and maximum for variety Padmini(59.87). This was due to the meteorological conditions prevailed during crop growth period. A variety PKVNL-260 was intermediate.

Similar results reported by ([http:// www.ijcm.as.com](http://www.ijcm.as.com)) and Verma *et al* (2005).

Effect of sowing times

The data regarding days to 50% flowering as influenced by sowing times are presented in Table 15. Days to 50% flowering was significantly influenced by different sowing times.

Sowing during 45th MW recorded minimum days to 50% flowering (54.44) and maximum for 48th MW (61) due to favourable climatic conditions enjoyed by 45th MW. Similar results reported by Naik and Satapathy (2000).

Effect of interaction

The interaction between varieties and sowing times were significant for mean days to 50% flowering at all the growth stages (Table 17). When variety NL-97 sown during 45th MW taken less number of days

(52.33) as compared to rest of the interactions between varieties and sowing times.

Table 17. Mean days to 50% flowering and days to maturity as influenced by different treatments

Treatment	Days to 50% Flowering	Days to maturity
A. Varieties (V)		
V ₁ : PKVNL-260	58.67	108.53
V ₂ : NL-97	55.80	110.80
V ₃ : Padmini	59.87	112.06
S.E. m $\pm$	0.43	0.57
C.D. at 5%	1.75	2.30
B. Sowing times (S)		
S ₁ : 44 MW	56.56	113.89
S ₂ : 45 MW	54.44	105.67
S ₃ : 46 MW	58.22	113.67
S ₄ : 47 MW	60.33	113.67
S ₅ : 48 MW	61.00	105.22
S.E. m $\pm$	0.36	0.42
C.D. at 5%	1.06	1.23
C. Interaction (VxS)		
S.E. m $\pm$	0.97	1.074
C.D. at 5%	2.09	2.48
General mean	58.11	110.47

Table 18 . Mean days to 50% flowering as influenced by interaction between varieties and sowing times

Sowing times Varieties	S₁ (44MW)	S₂ (45MW)	S₃ (46MW)	S₄ (47MW)	S₅ (48MW)	Mean
V ₁ -PKVNL-260	58.00	55.67	58.00	60.33	61.33	58.67
V ₂ - NL-97	54.00	52.33	56.33	56.66	59.66	55.80
V ₃ -Padmini	57.67	55.33	60.33	64.00	62.00	59.87
Mean	56.56	54.44	58.22	60.33	61.00	
S.E. m ±	0.97					
C.D. at 5%	2.09					

4.2.6 Days to maturity

The data pertaining to days to maturity as influenced by different treatments are presented in Table 15 and depicted in Fig. 7. The days to maturity was significantly influenced due to varieties and sowing times.

The data presented in Table 15 revealed that the mean days to maturity was (110.47).

Effect of varieties

The data presented in Table 15 revealed that days to maturity were significantly influenced due to varieties. A variety PKVNL-260 recorded minimum days to maturity (108.53) and maximum for variety Padmini(112.06). This was due to the meteorological conditions prevailed during crop growth period. Similar results reported by (<http://www.ijcm.as.com>) and Verma *et al.* (2005).

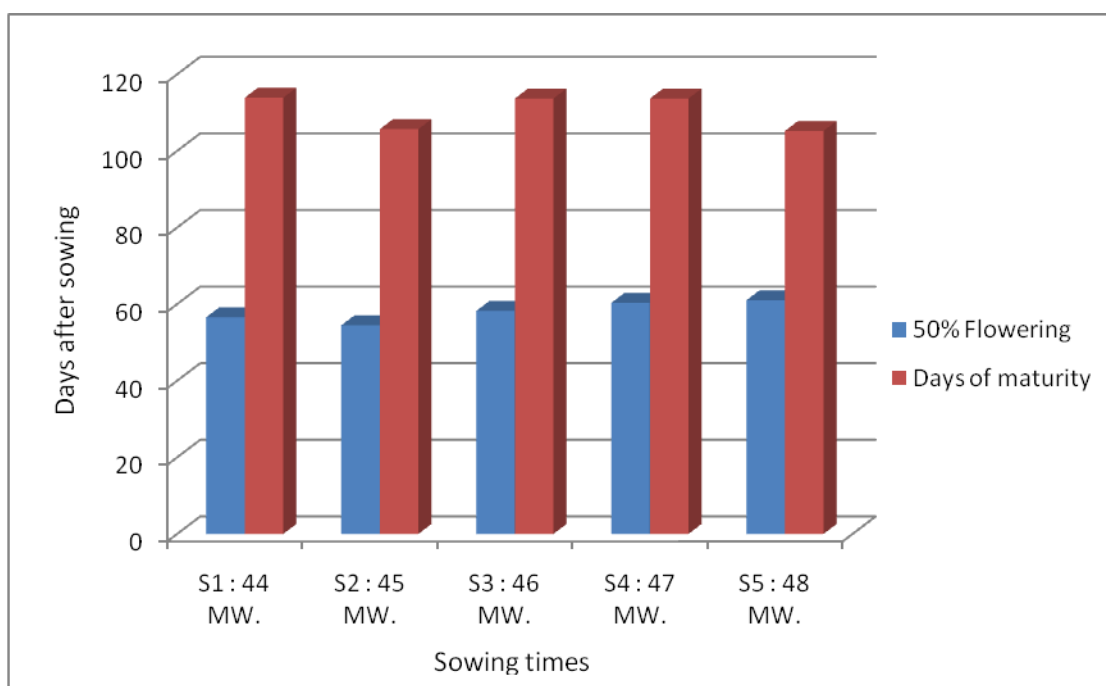
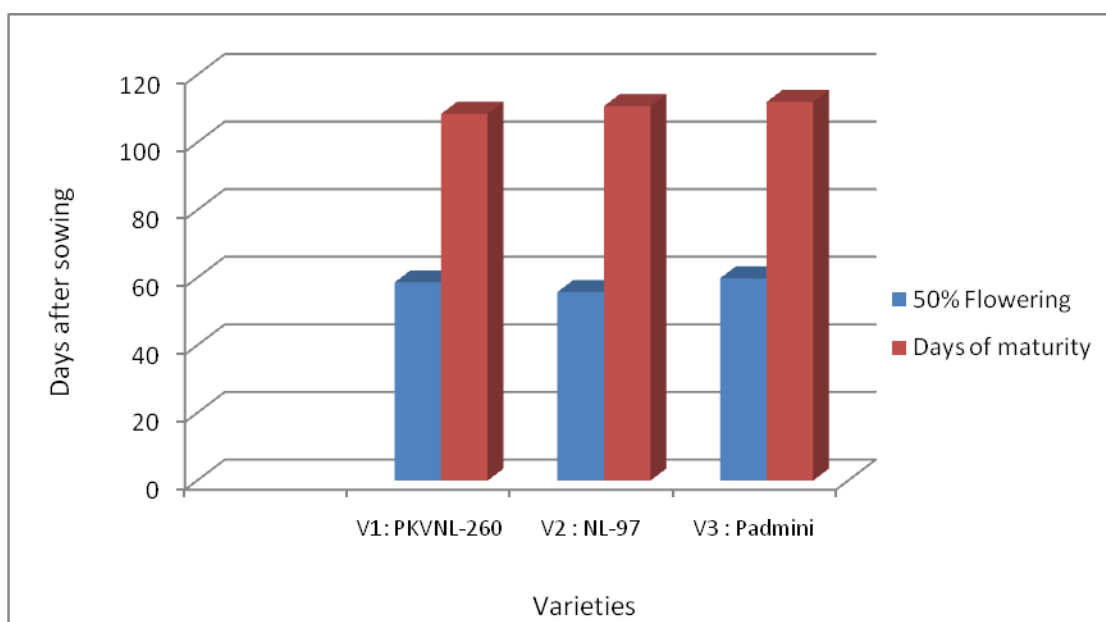


Fig.7. Days to 50% flowering and days to maturity as influenced periodically by varieties and sowing times

Effect of sowing times

The data regarding days to maturity as influenced by sowing times are presented in Table 15. Days to maturity was significantly influenced by different sowing times.

Sowing during 48th MW recorded minimum days to maturity (105.22) and maximum for 44th MW (113.89) due to favourable climatic conditions enjoyed by 48th MW. Similar results reported by Naik and Satapathy (2000).

Effect of interaction

The interaction between varieties and sowing times were significant for mean days to maturity at all the growth stages (Table 19). When variety NL-97 sown during 45th MW taken less number of days (105) as compared to rest of the interactions between varieties and sowing times.

Table 19 . Mean days to maturity as influenced by interaction between varieties and sowing times

Sowing times Varieties	S₁ (44MW)	S₂ (45MW)	S₃ (46MW)	S₄ (47MW)	S₅ (48MW)	Mean
V ₁ -PKVNL-260	111.33	105.67	112.00	109.00	104.67	108.53
V ₂ - NL-97	114.33	105.00	113.66	115.33	105.67	110.80
V ₃ -Padmini	116.00	106.33	116.00	116.67	105.33	112.07
Mean	113.89	105.67	113.89	113.67	105.22	
S.E. m ±	1.074					
C.D. at 5%	2.479					

4.3 Post harvest studies

The data pertaining to yield contributing characters recorded at harvest are presented in Table 20.

4.3.1 Number of capsules per plant

The data pertaining to mean number of capsules per plant at harvest as influenced by different treatments are presented in Table 20. The number of capsules per plant at harvest was significantly influenced due to varieties and sowing times.

The data presented in Table 20 revealed that the mean number of capsules per plant at harvest was 51.78

.Effect of varieties

The data pertaining to mean number of capsules per plant at harvest as influenced by varieties are presented in Table 20. It was significantly influenced by different varieties.

A variety PKVNL-260 recorded maximum number of capsules per plant (54.87) due to less flower drop and more fruit setting and minimum by NL-97 (49.80) due to their respective yield potentials. Similar results reported by ([http:// www.ijcm.as.com](http://www.ijcm.as.com)) and Verma *et al.* (2005).

Effect of sowing times

The data pertaining to mean number of capsules per plant at harvest as influenced by sowing times are presented in Table 20. It was significantly influenced by different sowing times.

Sowing during 45th MW recorded maximum number of capsules per plant (57.00). This was due to lower temperature during flowering resulted in low flower drop and more fruit setting during *rabi* season. Similar results reported by Yadav *et al.* (2002) and Tomar and Mishra (1991).

Table 20 .Yield contributing characters of linseed as affected by different treatments at harvest

Treatment	No. of capsules/ plant	Wt. of capsules/ plant(g)	Wt. of seeds/ plant(g)	Test wt. (g)	No. of seeds/ capsule
A. Varieties (V)					
V ₁ : PKVNL-260	54.87	3.36	2.86	7.99	8.78
V ₂ : NL-97	49.8	3.07	2.63	7.81	8.10
V ₃ : Padmini	50.67	3.13	2.74	7.92	8.27
S.E. m $\pm$	0.187	0.033	0.011	0.013	0.049
C.D. at 5%	0.752	0.132	0.045	0.052	0.197
B. Sowing times (S)					
S ₁ : 44 MW	55.22	3.42	3.06	8.04	8.72
S ₂ : 45 MW	57.00	3.53	3.20	8.27	9.00
S ₃ : 46 MW	54.11	3.36	2.79	7.82	8.49
S ₄ : 47 MW	48.56	3.01	2.62	7.78	7.94
S ₅ : 48 MW	44.00	2.62	2.04	7.61	7.64
S.E. m $\pm$	0.184	0.027	0.014	0.017	0.10
C.D. at 5%	0.541	0.08	0.043	0.049	0.294
C. Interaction (V x S)					
S.E. m $\pm$	0.417	0.073	0.025	0.029	0.109
C.D. at 5%	1.042	0.159	NS	0.091	NS
General mean	51.78	3.19	2.74	7.91	8.36

Effect of interaction

The interaction between varieties and sowing times were significant for number of capsules per plant at harvest (Table 21).

A linseed variety PKVNL-260 when sown during 45th MW registered the highest number of capsules per plant (57.00). The increase in number of capsules during 45th MW sowing was due to congenial climatic situation prevailed resulted in less flower drop and more fruit setting with more number of branches and capsules plant⁻¹.

Table 21 . Mean number of capsules per plant as influenced by interaction between varieties and sowing times

Sowing times Varieties	S₁ (44MW)	S₂ (45MW)	S₃ (46MW)	S₄ (47MW)	S₅ (48MW)	Mean
V ₁ -PKVNL-260	58.33	60.67	56.00	54.00	45.33	54.87
V ₂ - NL-97	53.33	55.33	52.67	44.67	43.00	49.80
V ₃ -Padmini	54.00	55.00	53.67	47.00	43.67	50.67
Mean	55.22	57.00	54.11	48.56	44.00	
S.E. m ±	0.417					
C.D. at 5%	1.042					

4.3.2 Weight of capsules per plant (g)

The data pertaining to weight of capsules per plant as influenced by different treatments are presented in Table 20. The weight of capsules per plant was significantly influenced due to varieties and sowing times.

The data presented in Table 20 revealed that the mean weight of capsules plant⁻¹ was 3.19 (g).

Effect of varieties

The data pertaining weight of capsules per plant at harvest as influenced by varieties are presented in Table 20. It was significantly influenced by different varieties.

A variety PKVNL-260 recorded maximum weight of capsules per plant (3.36 g.) and minimum by NL-97 (3.07 g.) due to their respective yield potentials. Similar results reported by ([http:// www.ijcm.as.com](http://www.ijcm.as.com)).

Effect of sowing times

The data pertaining to the weight of capsules per plant at harvest as influenced by sowing times are presented in Table 20. It was not significantly influenced by different varieties.

Sowing during 45th MW recorded maximum weight of capsules per plant (3.53 g.) and minimum by 48th MW (2.62 g). Similar results reported by Yadav *et al.* (2002).

Effect of interaction

The interaction between varieties and sowing times were significant for weight of capsules per plant at harvest (Table 22). When variety PKVNL-260 sown during 45th MW produced maximum weight of capsules plant⁻¹ (3.75 g) as compared to rest of the interactions between varieties and sowing times.

Table 22 . Mean weight of capsules per plant as influenced by interaction between varieties and sowing times

Sowing times Varieties	S₁ (44 MW)	S₂ (45 MW)	S₃ (46 MW)	S₄ (47 MW)	S₅ (48 MW)	Mean
V ₁ -PKVNL-260	3.61	3.75	3.45	3.38	2.62	3.36
V ₂ - NL-97	3.32	3.41	3.31	2.74	2.58	3.07
V ₃ -Padmini	3.34	3.42	3.32	2.91	2.66	3.13
Mean	3.42	3.53	3.36	3.01	2.62	
S.E. m ±	0.073					
C.D. at 5%	0.159					

4.3.3 Weight of seeds per plant (g)

The data pertaining to mean weight of seeds per plant as influenced by different treatments are presented in Table 20. The weight of seeds per plant was significantly influenced due to varieties and sowing times.

The data presented in Table 20 revealed that the mean weight of seed plant⁻¹ was 2.74 g.

Effect of varieties

The data pertaining to mean weight of seeds per plant at harvest as influenced by varieties are presented in Table 20. It was significantly influenced by different varieties.

A variety PKVNL-260 recorded maximum seed yield (2.86 g plant⁻¹) (Table 20). This was due to more number of branches per plant which in turn production of more number of matured or productive capsules. Similar results reported by ([http:// www.ijcm.as.com](http://www.ijcm.as.com)).

Effect of sowing times

The data pertaining to mean weight of seeds per plant at harvest as influenced by different times are presented in Table 20. It was significantly influenced by different sowing times.

Sowing of linseed during 45th MW recorded maximum seed yield (3.20 g plant⁻¹). This was due to optimum temperature prevailed during flowering resulted in low flower drop and more fruit setting during the period (Table 20). Similar results reported by Yadav *et al.* (2002).

Effect of interaction

The interaction between varieties and sowing time for weight of seeds plant⁻¹ was non- significant.

4.3.4 Thousand seed weight [Test weight (g)]

Thousand seed weight was influenced by varieties and sowing time in linseed. The data presented in Table 20 revealed that the mean thousand seed weight was (7.91 g).

Effect of varieties

The data pertaining to thousand seed weight at harvest as influenced by varieties are presented in Table 20. It was significantly influenced by different varieties.

Thousand seed weight was influenced significantly by different varieties of linseed. The mean 1000 seed weight of PKVNL-260 variety was (7.99 g) and higher than other varieties.

This might be due to more number of branches produced more number of productive capsules. Similar results reported by (<http://www.ijcm.as.com>).

Effect of sowing time

The data pertaining to thousand seed weight at harvest as influenced by sowing times are presented in Table 17. It was significantly influenced by different sowing times.

Sowing of linseed during 45th MW significantly influenced significantly more mean 1000 seed weight (8.27 g.) than other sowing times (Table 20). Sowing at 45th MW increased number of filled capsules thereby more seed weight resulted in 1000 seed weight. Similar results reported by Tomar and Mishra (1991).

Effect of interaction

The interaction between varieties and sowing times were significant for test weight at harvest (Table 23). A linseed variety PKVNL-260 when sown during 45th MW registered the highest test weight (8.27 g.) than rest of the interactions between varieties and sowing times.

4.3.5 Number of seeds/capsule

The data pertaining to mean number of seeds per capsule as influenced by different treatments are presented in Table 20. The mean number of seeds per plant was significantly influenced due to varieties and sowing times. The data presented in Table 17 revealed that the mean number of seeds plant⁻¹ was (8.36).

Effect of varieties

The data pertaining to mean number of seeds per plant at harvest as influenced by varieties are presented in Table 20. It was significantly influenced by different varieties.

A variety PKVNL-260 recorded maximum number of seeds (8.78) (Table 20). This was due to more number of filled seeds per

Table 23 . Mean test weight (g) as influenced by interaction between varieties and sowing times

Sowing times Varieties	S₁ (44 MW)	S₂ (45 MW)	S₃ (46 MW)	S₄ (47 MW)	S₅ (48 MW)	Mean
V ₁ -PKVNL-260	8.13	8.43	7.93	7.83	7.63	7.99
V ₂ - NL-97	7.93	8.13	7.70	7.70	7.57	7.81
V ₃ -Padmini	8.07	8.23	7.83	7.83	7.63	7.92
Mean	8.04	8.27	7.82	7.79	7.61	
S.E. m ±	0.029					
C.D. at 5%	0.091					

capsule which in turn seed yield. Similar results reported by (<http://WWW.ijcm.as.com>).

Effect of sowing times

The data pertaining to mean number of seeds per capsule at harvest as influenced by different sowing times are presented in Table 20. It was significantly influenced by different sowing times.

Sowing of linseed during 45th MW recorded maximum number of seeds per capsule (9.00). This was due to optimum temperature prevailed during capsule development and more seed setting during the period (Table 20). Similar result was reported by Yadav *et al.* (2002).

Effect of interaction

The interaction between varieties and sowing time for mean number of seeds capsule⁻¹ was non- significant (Table 20).

4.4 Yield

The data pertaining to the seed and straw yields as influenced by different treatments are presented in Table 21 and depicted in Fig. 8.

4.4.1 Grain yield

The data presented in Table 24 indicated that mean seed yield was 17.06 q ha⁻¹. Seed yield was influenced by different treatments.

Effect of varieties

The data pertaining to grain yield of linseed at harvest as influenced by different varieties are presented in Table 24. It was significantly influenced by varieties.

A variety PKVNL-260 recorded maximum seed yield (17.33 q ha⁻¹) and was superior over rest of the varieties. This was due to less flower drop, more number of branches, more number of filled capsules plant⁻¹ and more grain weight plant⁻¹ helped in more seed yield (q ha⁻¹). Similar results reported by ([http:// www.ijcm.as.com](http://www.ijcm.as.com)).

Effect of sowing times

The data pertaining to grain yield of linseed at harvest as influenced by sowing times are presented in Table 24. It was significantly influenced by different sowing times.

Sowing of linseed at 45th MW recorded maximum seed yield (17.81 q ha⁻¹). This was due to optimum temperature prevailed during flowering resulted in low flower drop and higher fruit setting. A crop was also free from pests or diseases.

Similar results reported by Mathur *et al.* (1984), Tomar and Mishra (1991) and Yadav *et al.* (2002).

Effect of interaction

The effect of interaction between varieties and sowing times at harvest were found non-significant for seed yield and the relevant data are presented.

4.4.2 Straw yield (kg/ha)

The straw yield of linseed was affected by different treatment. The data presented in Table 24 revealed that the mean straw yield was 34.64 q/ ha.

Effect of varieties

The data pertaining to straw yield of linseed at harvest as influenced by different varieties are presented in Table 24 and graphically depicted in Fig.7. It was significantly influenced by varieties.

The straw yield was affected by different varieties (Table 21). A variety PKVNL-260 produced significantly higher straw yield (35.37 q ha⁻¹) than NL-97 and Padmini. More plant height, plant spread, number of branches and capsules contributed towards increased straw yield. Similar result was reported by ([http:// www.ijcm.as.com](http://www.ijcm.as.com)).

Effect of sowing times

The data pertaining to straw yield of linseed at harvest as influenced by sowing times are presented in Table 24. It was significantly influenced by different sowing times.

The linseed when sown during 45th MW produced maximum straw yield (36.24 q ha⁻¹). This was due to production of more number of capsules and branches plant⁻¹ (Table 24). Similar result was reported by Shahidullah *et al.* (1997).

Effect of interaction

Interaction effect between varieties and sowing times at harvest were found non-significant and the relevant data are presented .

Table 24 :Yield of linseed as affected by different treatments at harvest

Treatment	Yield (q/ha)		
	Grain	Straw	Biological
A. Varieties (V)			
V ₁ : PKVNL-260	17.33	35.37	52.70
V ₂ : NL-97	16.82	33.97	50.79
V ₃ : Padmini	17.02	34.59	51.61
S.E. m $\pm$	0.039	0.148	0.144
C.D. at 5%	0.158	0.597	0.580
B. Sowing times (S)			
S ₁ : 44 MW	17.52	35.67	53.19
S ₂ : 45 MW	17.81	36.24	54.05
S ₃ : 46 MW	17.19	34.79	51.98
S ₄ : 47 MW	16.85	34.28	51.12
S ₅ : 48 MW	15.92	32.25	48.16
S.E. m $\pm$	0.085	0.164	0.238
C.D. at 5%	0.250	0.482	0.700
C. Interaction (Vx S)			
S.E. m $\pm$	0.088	0.331	0.321
C.D. at 5%	NS	NS	NS
General mean	17.06	34.64	51.70

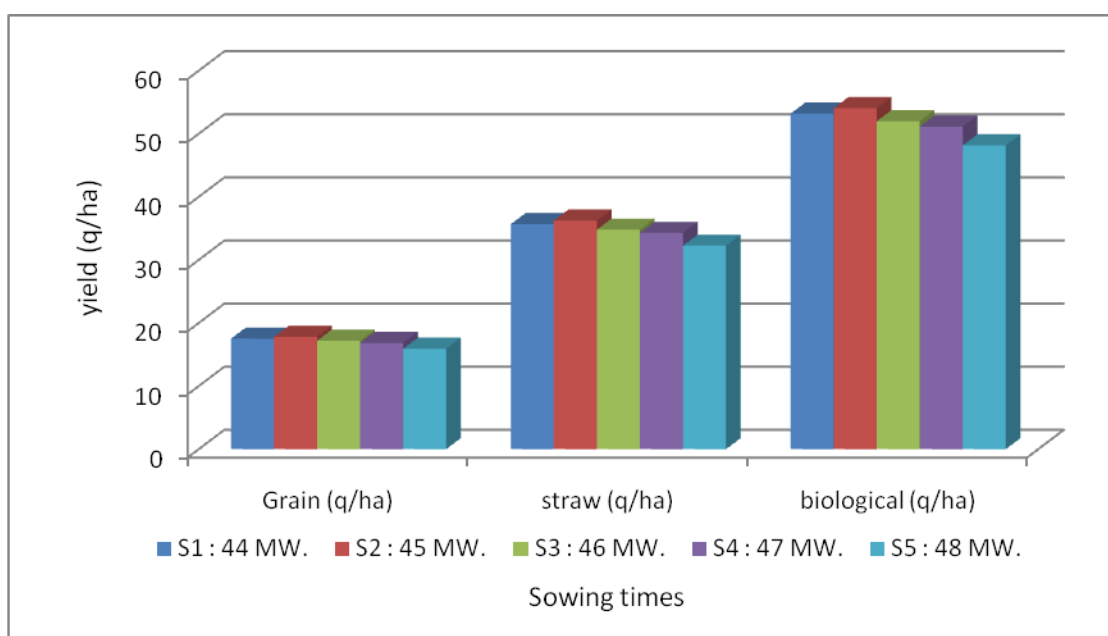
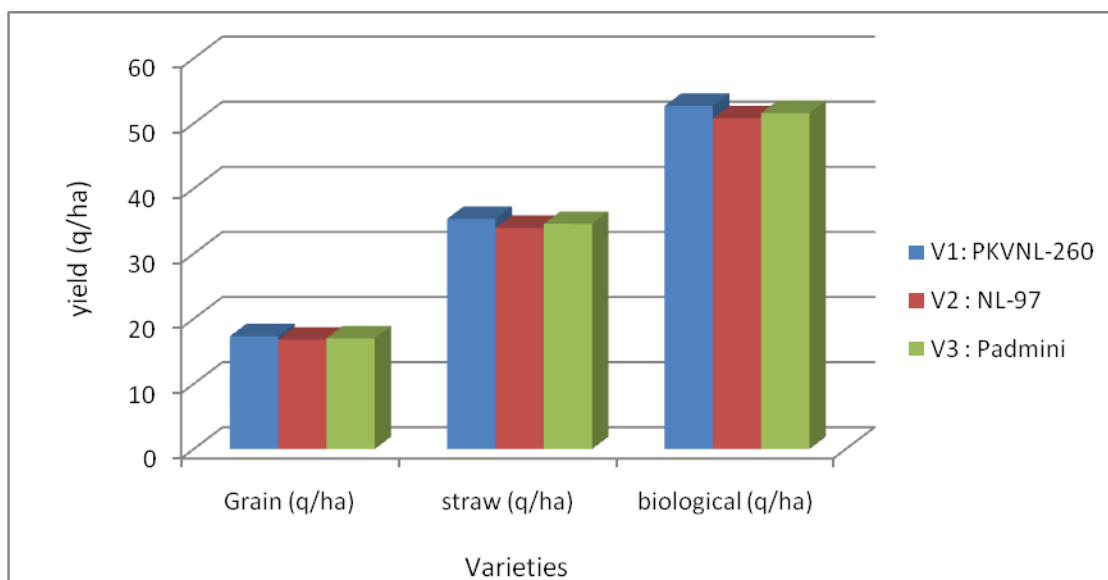


Fig.8. Grain, straw and biological yield (q/ha) as influenced periodically by varieties and sowing times

4.4.3 Biological yield

The data presented in Table 24 indicated that mean biological yield was 51.70 q ha⁻¹. Seed yield was affected by different treatments.

Effect of varieties

The data pertaining to grain yield of linseed at harvest as influenced by different varieties are presented in Table 24 and graphically depicted in Fig.7. It was significantly influenced by varieties.

A variety PKVNL-260 recorded maximum biological yield (52.70 q ha⁻¹) and was superior over rest of the varieties. This was due to less flower drop, more number of branches, more number of filled capsules plant⁻¹ and more grain weight plant⁻¹ helped in increased biological yield (q ha⁻¹).

Effect of sowing times

The data pertaining to biological yield of linseed at harvest as influenced by sowing times are presented in Table 24. It was significantly influenced by different sowing times.

Sowing at 45th MW recorded maximum biological yield (54.05 q ha⁻¹). This was due to optimum temperature prevailed during flowering resulted in low flower drop and higher fruit setting. A crop was also free from pests or diseases. Similar result was reported by Shahidullah *et al.* (1997).

Effect of interaction

The effect of interaction between varieties and sowing times at harvest were found non-significant (Table 24).

4.5 Meteorological observations

4.5.1 Growing degree days

The data on growing degree days are presented in Table 25. The growing degree days for *rabi* linseed were calculated by using daily maximum, minimum and base temperature of linseed (Table 25) and shown in figure 9.

The growing degree days varied with sowing time. The linseed sown during 48th MW showed maximum growing degree days (2246.95 heat units) with respect to sowing during 44th MW (2216.9 heat units), 45th MW (2153.55 heat units), 46th MW (2104.15 heat units) and 47th MW (2204.3 heat units) as more number of days and bright sunshine hours are associated with 48th MW sowing.

It is mainly due to difference in duration of crop growth and difference in maximum and minimum temperatures. Similar result was reported by Casa *et al.* (1999) and Agrawal *et al.* (2002).

Table 25: Details of growing degree days (heat unit) for *rabi* linseed as influenced periodically by different treatments

	Sowing Times				
Days after sowing	S ₁ (MW 44)	S ₂ (MW 45)	S ₃ (MW 46)	S ₄ (MW 47)	S ₅ (MW 48)
	Cumulative GDD	Cumulative GDD	Cumulative GDD	Cumulative GDD	Cumulative GDD
14 DAS	329.5	300.8	299.8	322.9	312.4
28 DAS	629.3	623.7	612.1	594.3	598.1
42 DAS	941.6	895.1	868.8	868.5	883.5
56 DAS	1198.3	1169.3	1154.2	1155.9	1180.8
70 DAS	1483.7	1418.3	1446.3	1453.3	1472.8
84 DAS	1775.75	1715.6	1648.3	1741.5	1767.3
At harvest	2216.9	2153.6	2104.2	2204.3	2246.9
Total	2216.9	2153.6	2104.2	2204.3	2246.9

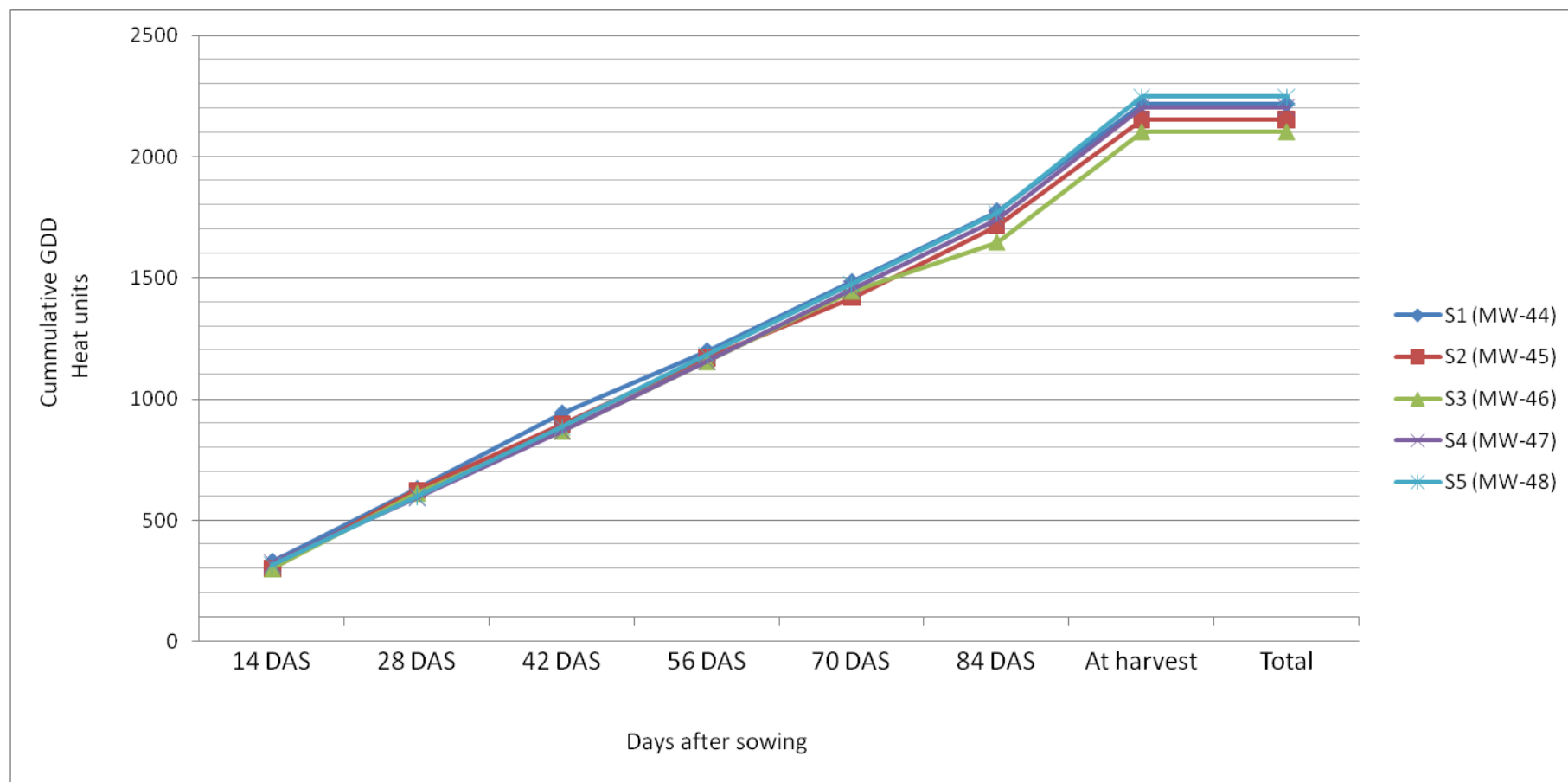


Fig. 9. Cumulative growing degree days (GDD) as influenced periodically by different treatments

4.5.2 Photo thermal unit

The data on photo thermal unit are presented in Table 26. The photo thermal unit for *rabi* linseed were calculated by using GDD multiply by day length (Table 25) and shown in fig.10.

The photo thermal unit varied with sowing time. The linseed sown during 48th MW showed higher photo thermal units (29210) with respect to sowing during 44th MW (28820), 45th MW (27996), 46th MW (27354) and 47th MW (28656) as more number of days and bright sunshine hours are associated with 48th MW sowing.

It is mainly due to difference in duration of crop growth and difference in photo thermal unit. Similar result were reported by Mokashi (1999) and Gourangakar and Chakravarty (1999).

4.5.3 Hydro thermal unit

The data on hydro thermal units are presented in Table 27. The hydro thermal unit for *rabi* linseed were calculated by using GDD multiply by mean relative humidity (Table 27) and shown in fig. 11.

The hydro thermal units varied with sowing time. The linseed sown during 48th MW showed maximum hydro thermal unit (136989) with respect to sowing during 44th MW (135674), 45th MW (127275), 46th MW (123268) and 47th MW (133103) as more number of days and relative humidity are associated with 48th MW sowing.

It was mainly due to difference in duration of crop growth and difference in hydro thermal units.

Similar results were reported by Mokashi (1999) and Gourangakar and Chakravarty (1999).

Table 26 : Details of photo thermal unit for *rabi* linseed as influenced periodically by different treatments

	Sowing Times				
Days after sowing	S ₁ (MW 44)	S ₂ (MW 45)	S ₃ (MW 46)	S ₄ (MW 47)	S ₅ (MW 48)
	Cumulative Photo thermal units	Cumulative Photo thermal units	Cumulative Photo thermal units	Cumulative Photo thermal Units	Cumulative Photo thermal Units
14 DAS	4284	3910	3897	4197.05	4060.55
28 DAS	8180	8107	7957	7725	7775
42 DAS	12241	11636	11294	11290	11485
56 DAS	15578	15200	15005	15027	15350
70 DAS	19288	18437	18801	18892	19146
84 DAS	23085	22302	21428	22639	22975
At harvest	28820	27996	27354	28656	29210
Total	28820	27996	27354	28656	29210

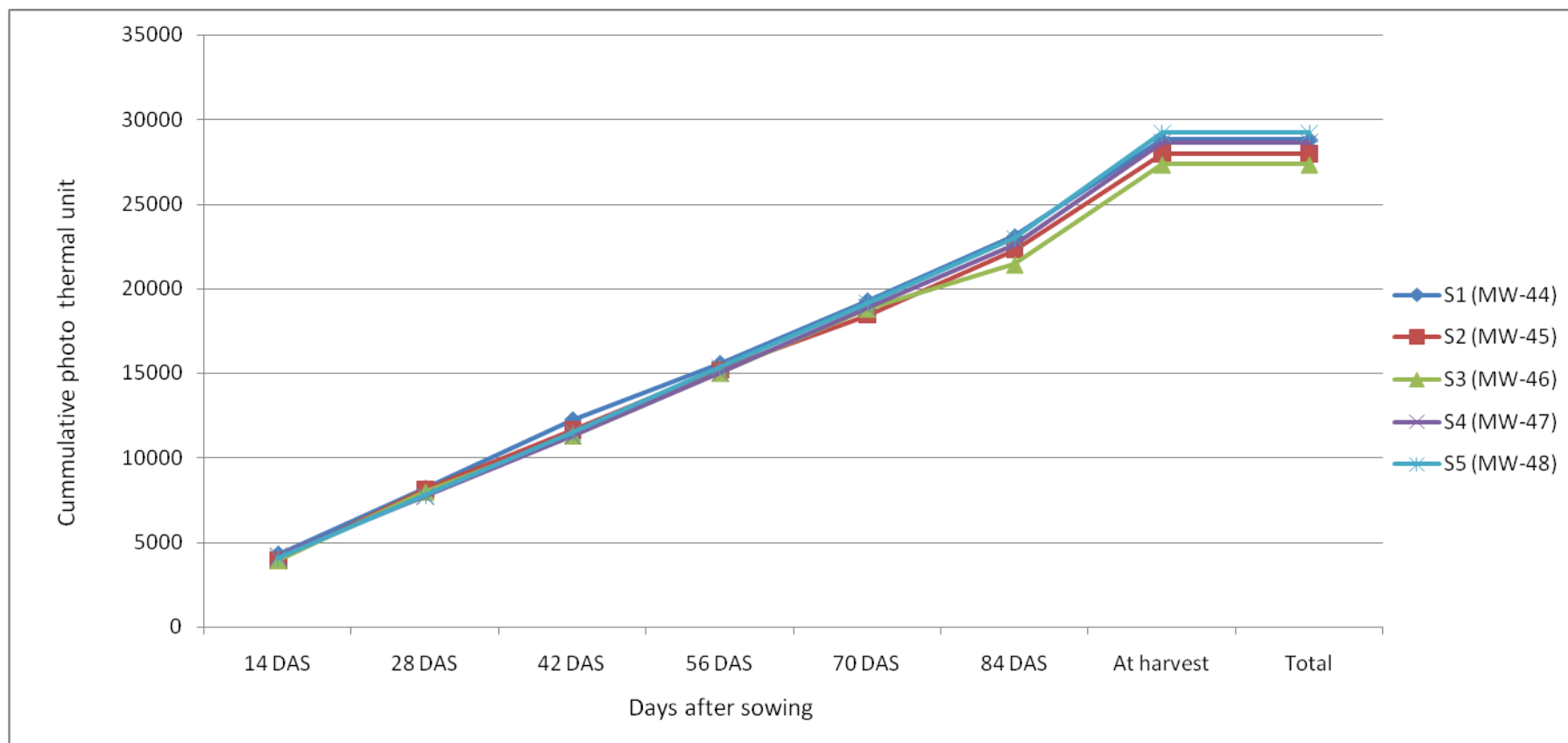


Fig. 10. Cumulative photo thermal unit as influenced periodically by different treatments

Table 27: Details of hydro thermal unit for *rabi* linseed as influenced periodically by different treatments

	Sowing Times				
Days after sowing	S₁ (MW 44)	S₂ (MW 45)	S₃ (MW 46)	S₄ (MW 47)	S₅ (MW 48)
	Cumulative Hydro thermal unit	Cumulative Hydro thermal unit	Cumulative Hydro thermal unit	Cumulative Hydro thermal Unit	Cumulative Hydro thermal unit
14 DAS	21294	19281	19214	22301	21607
28 DAS	40335	43079	42342	37007	36705
42 DAS	65135	55739	53323	57405	59964
56 DAS	73546	77287	78341	75252	75775
70 DAS	100706	92328	92813	94171	94738
84 DAS	113959	111168	106027	103224	100471
At harvest	135674	127275	123268	133103	136989
Total	135674	127275	123268	133103	136989

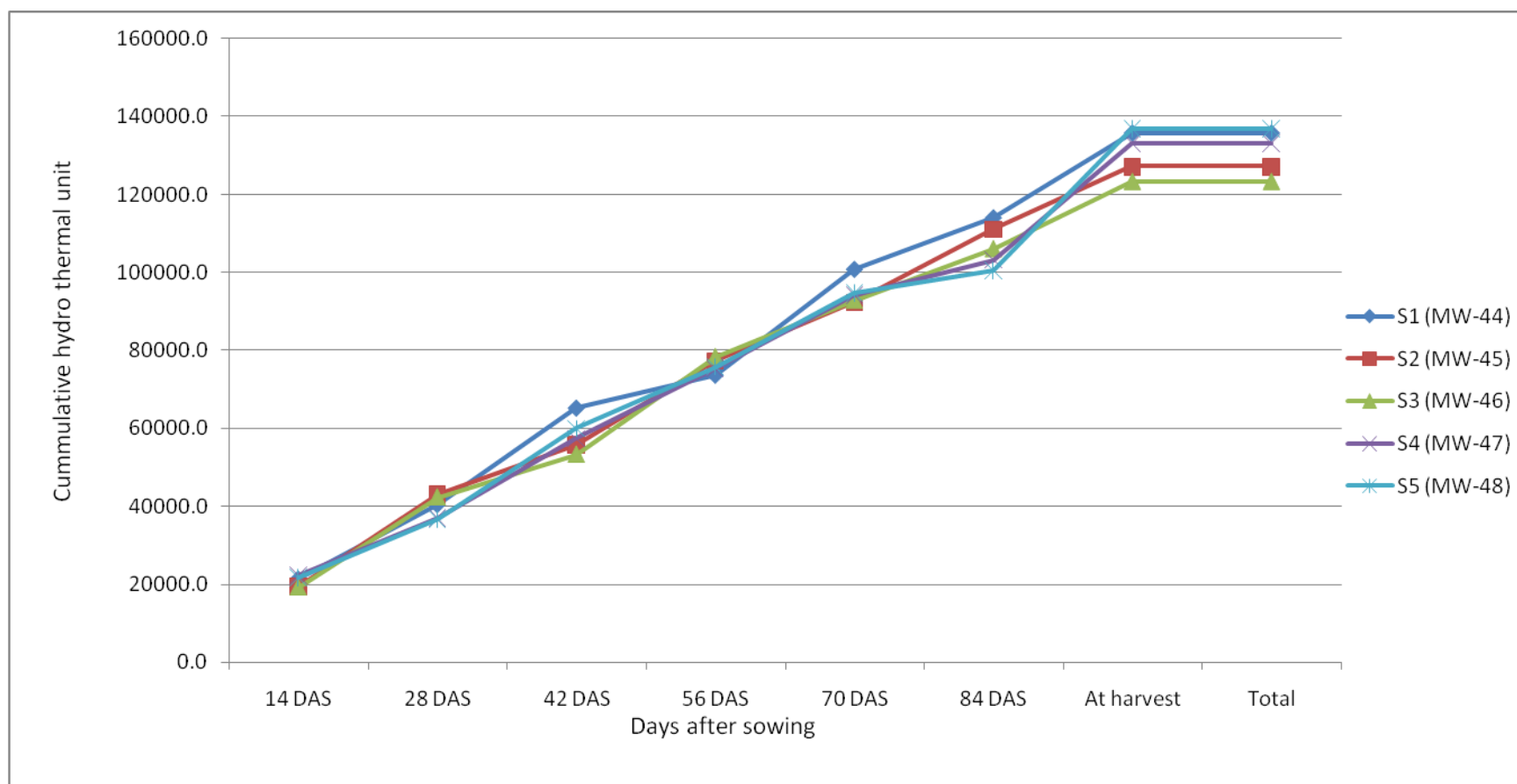


Fig. 11. Cumulative hydro thermal unit as influenced periodically by different treatments

4.5.4 Photosynthetically active radiation (PAR)

4.5.4.1 Incident radiation (PAR):

Photosynthetically active radiation of linseed at different growing stages in different treatments was calculated by using quantum sensor reading (Table 28) and depicted in Fig.12.

Mean incident photosynthetically active radiation increased with increase in temperature. The mean value of incident PAR were 1614.05, 1488.75, 1427.13, 1538.43, 1644.52, 1720.45 and 1742.71 ($\mu \text{ mol m}^{-2} \text{ s}^{-1}$) at 14, 28, 42, 56, 70, 84 and at harvest, respectively.

Among all the treatments, the variety Padmini sown during 48th MW gave maximum PAR values at harvest (1766.04 $\mu \text{ mol m}^{-2} \text{ s}^{-1}$) which was at par with the PKVNL-260 sown during 48th MW (1737.98 $\mu \text{ mol m}^{-2} \text{ s}^{-1}$). The incident radiation was generally depends upon the weather condition of the day. The low incident radiations were observed when cloudy condition remained while recording the observations.

4.5.4.2 Canopy reflected radiation:

Mean reflected photosynthetically active radiation increased with increase in canopy (Table 29 and fig. 13). The mean value of reflected PAR were 135.59, 158.71, 179.12, 206.78, 242.74, 270.12, and 303.33 ($\mu \text{ mol m}^{-2} \text{ s}^{-1}$) at 14, 28, 42, 56, 70, 84 and at harvest, respectively.

Among all the treatments, the variety Padmini sown during 48th MW record maximum reflected PAR values at harvest (308.64 $\mu \text{ mol m}^{-2} \text{ s}^{-1}$) which was at par with the PKVNL-260 sown during 48th MW (302.89 $\mu \text{ mol m}^{-2} \text{ s}^{-1}$). The reflected radiation depends upon the intensity of incident radiation and position of plant organs to the incident radiation. Similar result was reported by Singh (2002).

Table 28 : Incideant Photosynthetically active radiation (PAR) ($\mu \text{ mol m}^{-2}\text{s}^{-1}$) by *rabi* linseed as influenced periodically by different treatment

Treat ment	Days after sowing(DAS)						
	14	28	42	56	70	84	At harvest
V₁S₁	1574.11	1448.81	1387.18	1498.49	1604.57	1680.50	1702.77
V₁S₂	1592.11	1466.81	1405.18	1516.49	1622.57	1698.50	1720.77
V₁S₃	1595.45	1470.15	1408.52	1519.83	1625.91	1701.84	1724.11
V₁S₄	1602.56	1477.26	1415.63	1526.94	1633.02	1708.95	1731.22
V₁S₅	1609.32	1484.02	1422.39	1533.7	1639.78	1715.71	1737.98
V₂S₁	1616.28	1490.98	1429.35	1540.66	1646.74	1722.67	1744.94
V₂S₂	1622.38	1497.08	1435.45	1546.76	1652.84	1728.77	1751.04
V₂S₃	1624.24	1498.94	1437.31	1548.62	1654.70	1730.63	1752.9
V₂S₄	1627.36	1502.06	1440.43	1551.74	1657.82	1733.75	1756.02
V₂S₅	1630.28	1504.98	1443.35	1554.66	1660.74	1736.67	1758.94
V₃S₁	1633.09	1507.79	1446.16	1557.47	1663.55	1739.48	1761.75
V₃S₂	1617.86	1492.56	1430.93	1542.24	1648.32	1724.25	1746.52
V₃S₃	1619.39	1494.09	1432.46	1543.77	1649.85	1725.78	1748.05
V₃S₄	1609.05	1483.75	1422.12	1533.43	1639.51	1715.44	1737.71
V₃S₅	1637.38	1512.08	1450.45	1561.76	1667.84	1743.77	1766.04
Mean	1614.05	1488.75	1427.13	1538.43	1644.52	1720.45	1742.71

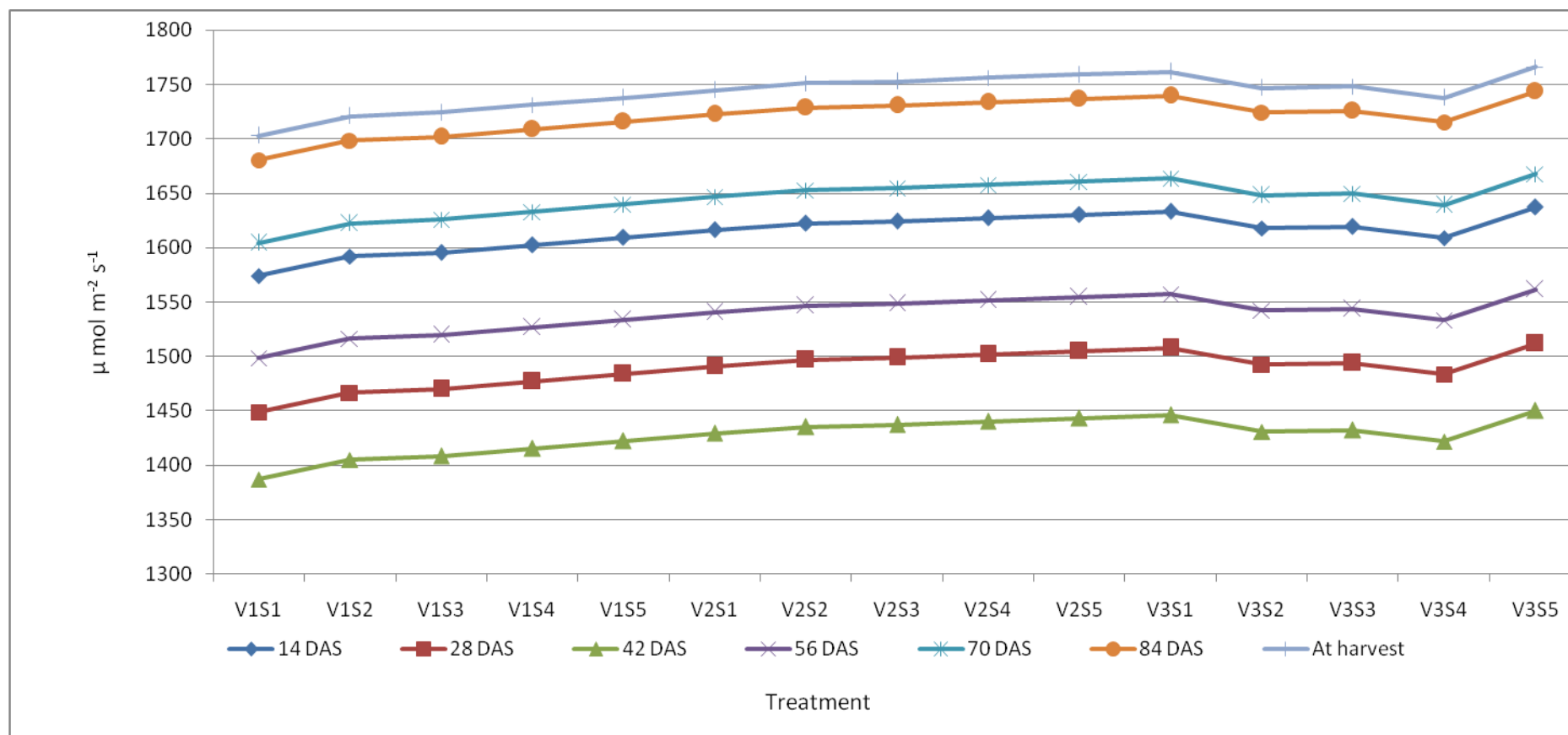


Fig.12.Incident Photosynthetically active radiation (PAR) ($\mu \text{mol m}^{-2} \text{s}^{-1}$) by *rabi* linseed as influenced periodically by different treatments

Table 29: Photosynthetically active radiation (PAR) ($\mu \text{ mol m}^{-2} \text{ s}^{-1}$) canopy reflected by *rabi* linseed as influenced periodically by different treatment

Treatment	Days after sowing(DAS)						
	14	28	42	56	70	84	At harvest
V₁S₁	130.96	153.28	172.98	200.19	235.55	262.49	295.29
V₁S₂	131.98	154.74	174.80	202.14	237.70	264.79	297.69
V₁S₃	133.22	155.98	176.06	203.50	239.17	266.33	299.33
V₁S₄	134.61	157.47	177.66	205.22	241.03	268.30	301.41
V₁S₅	135.50	158.49	178.79	206.43	242.36	269.71	302.89
V₂S₁	135.44	158.64	179.09	206.75	242.73	270.11	303.30
V₂S₂	135.63	158.98	179.57	207.26	243.29	270.72	303.94
V₂S₃	136.76	160.08	180.67	208.44	244.56	272.05	305.35
V₂S₄	138.16	161.47	182.07	209.95	246.18	273.76	307.17
V₂S₅	138.73	162.08	182.72	210.65	246.95	274.56	308.02
V₃S₁	136.85	160.42	181.20	209.01	245.20	272.75	306.07
V₃S₂	134.92	158.21	178.72	206.35	242.30	269.67	302.82
V₃S₃	136.35	159.56	180.06	207.79	243.84	271.29	304.55
V₃S₄	135.96	158.90	179.18	206.85	242.81	270.18	303.40
V₃S₅	138.84	162.39	183.19	211.15	247.50	275.16	308.64
Mean	135.59	158.71	179.12	206.78	242.74	270.12	303.33

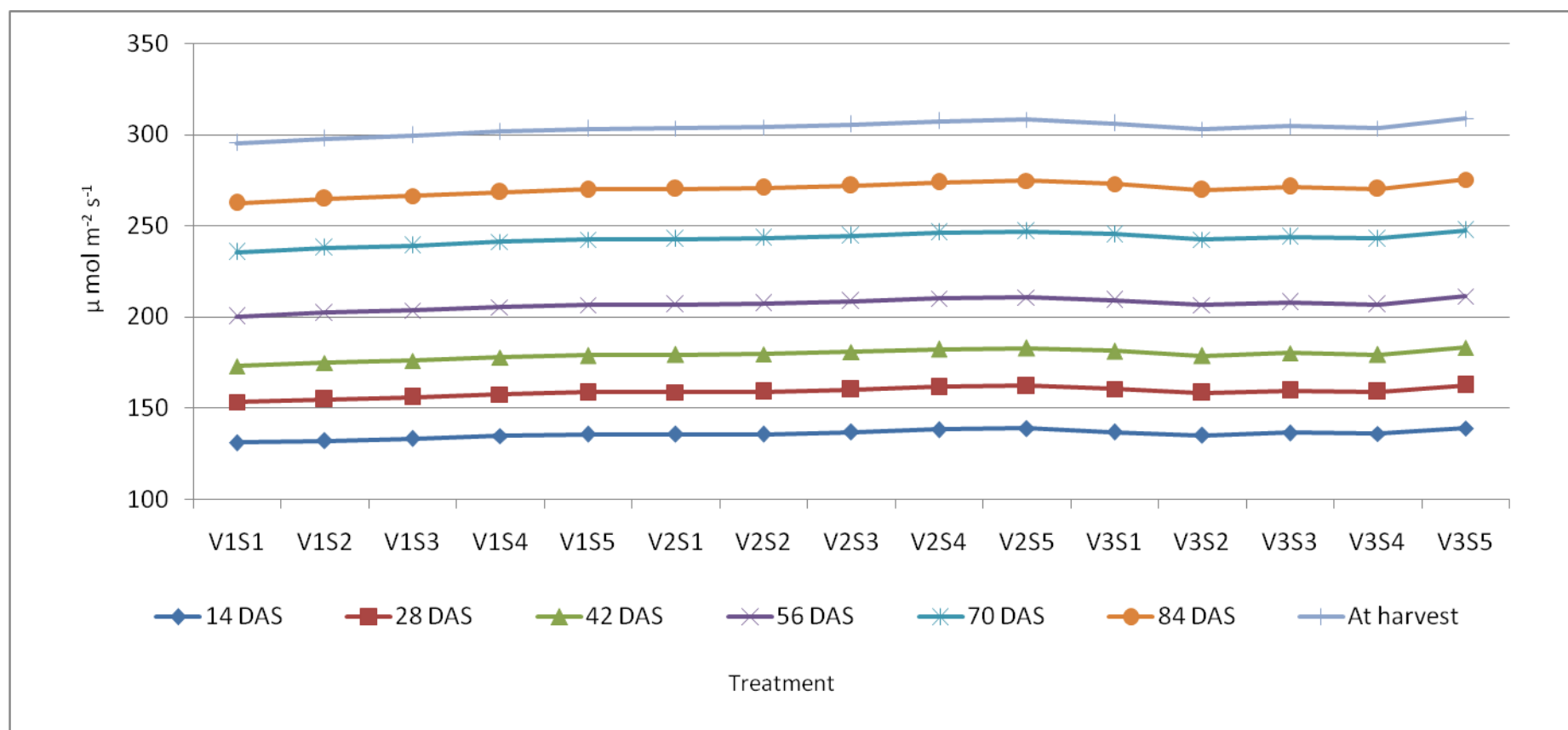


Fig.13. Canopy reflected Photosynthetically active radiation (PAR) ($\mu \text{ mol m}^{-2} \text{ s}^{-1}$) by *rabi* linseed as influenced periodically by different treatments

4.5.4.3 Transmitted radiation through canopy

The observations of transmitted radiation were recorded at 14 days intervals. data on transmitted radiation cumulated at fourteen days intervals is presented in Table.30 and illustrated in Fig. 14.

It was noticed that fourteen days mean transmitted radiation at noon under open condition was found lowest ($654.82\mu\text{molm}^{-2}\text{s}^{-1}$) at 70 DAS when variety PKVNL-260 sown during 44th MW. Further, the lowest mean transmitted radiation ($673.33\mu\text{molm}^{-2}\text{s}^{-1}$) was observed at 70 DAS and the highest was observed ($1204.45\mu\text{molm}^{-2}\text{s}^{-1}$) in treatment with V_2S_5 at 14 DAS.

Thus, it can be concluded that the transmission of radiation was decreased with increase in canopy which was clearly depicted in Fig. 13 and Table 30. Similar result was reported by Singh (2002).

4.5.4.4 Soil reflected radiation:

Mean reflected photosynthetically active radiation decreased with increase in canopy(Table 31) and Fig 15. The mean value of reflected PAR were 115.95, 87.00, 77.40, 70.83,70.12, 68.54 and 76.72 ($\mu\text{mol m}^{-2}\text{s}^{-1}$) at 14, 28, 42, 56, 70, 84 and at harvest, respectively.

Among all the treatments, the variety Padmini sown during 45th MW gave minimum reflected PAR values at harvest ($72.64\mu\text{mol m}^{-2}\text{s}^{-1}$) which was at par with the NL-97 sown during 48th MW ($80.67\mu\text{mol m}^{-2}\text{s}^{-1}$).The reflected radiation depends upon the intensity of incident radiation and position of plant organs to the incident radiation.

Table 30 : Photosynthetically active radiation (PAR) ($\mu \text{ mol m}^{-2} \text{ s}^{-1}$) transmitted by *rabi* linseed as influenced periodically by different treatments

DAYS AFTER SOWING(DAS)							
Treatment	14	28	42	56	70	84	At harvest
V₁S₁	1154.13	904.78	673.47	655.73	654.82	657.58	705.24
V₁S₂	1166.69	915.43	681.66	663.00	661.52	663.94	711.55
V₁S₃	1170.42	918.69	684.40	665.68	664.18	666.61	714.32
V₁S₄	1176.76	924.17	688.85	669.86	668.23	670.59	718.38
V₁S₅	1182.20	928.84	692.56	673.29	671.49	673.76	721.59
V₂S₁	1187.31	933.20	695.95	676.34	674.34	676.49	724.32
V₂S₂	1190.98	936.27	698.20	678.25	676.01	678.02	725.79
V₂S₃	1194.14	939.08	700.69	680.77	678.59	680.65	728.56
V₂S₄	1197.08	941.64	702.79	682.76	680.53	682.58	730.52
V₂S₅	1200.37	944.52	705.22	685.13	682.89	684.94	732.9
V₃S₁	1198.85	942.97	703.42	682.95	680.39	682.22	729.99
V₃S₂	1187.18	932.99	695.57	675.80	673.67	675.73	723.46
V₃S₃	1190.09	935.59	697.89	678.17	676.11	678.23	726.09
V₃S₄	1183.13	929.72	693.429	674.24	672.52	674.85	722.77
V₃S₅	1204.45	947.92	707.67	687.17	684.65	686.52	734.47
Mean	1185.59	931.72	694.78	675.28	673.33	675.51	723.33

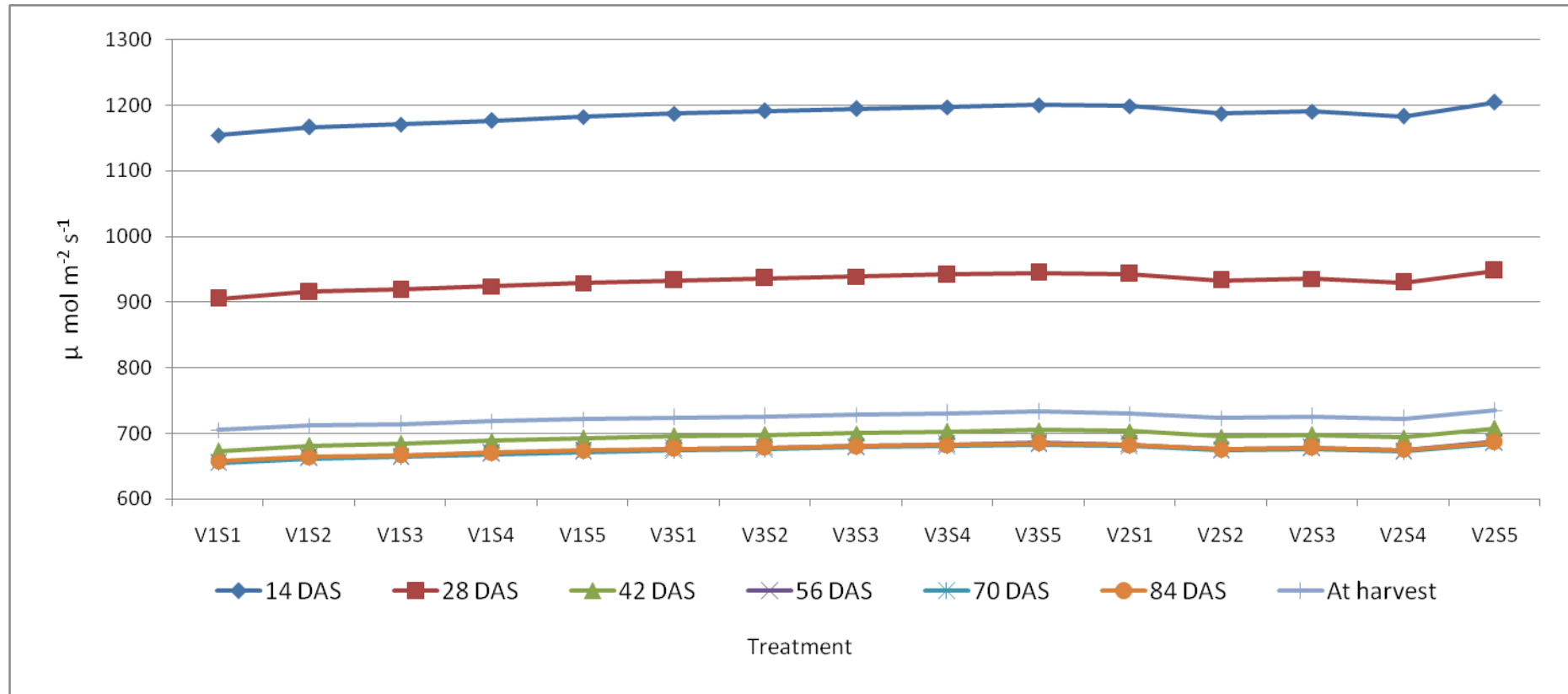


Fig.14. Transmitted Photosynthetically active radiation (PAR) ($\mu \text{ mol m}^{-2} \text{ s}^{-1}$) by *rabi* linseed as influenced periodically by different treatments

Table 31: Photosynthetically active radiation (PAR) ($\mu \text{ mol m}^{-2} \text{ s}^{-1}$) soil reflected by *rabi* linseed as influenced periodically by different treatments

Days after sowing(DAS)							
Treatment	14	28	42	56	70	84	At harvest
V ₁ S ₁	110.97	82.72	73.38	66.98	66.26	64.69	72.65
V ₁ S ₂	111.60	83.16	73.77	67.18	66.36	64.71	72.64
V ₁ S ₃	113.11	84.53	75.07	68.54	67.80	66.20	74.24
V ₁ S ₄	114.74	85.97	76.44	69.93	69.24	67.67	75.81
V ₁ S ₅	115.71	86.81	77.23	70.70	70.01	68.45	76.64
V ₂ S ₁	116.21	87.22	77.61	71.02	70.31	68.73	76.93
V ₂ S ₂	115.83	86.83	77.22	70.53	69.75	68.11	76.26
V ₂ S ₃	117.75	88.58	78.90	72.32	71.64	70.09	78.37
V ₂ S ₄	118.63	89.37	79.65	73.08	72.44	70.91	79.25
V ₂ S ₅	119.98	90.59	80.82	74.31	73.73	72.24	80.67
V ₃ S ₁	116.60	87.45	77.80	71.02	70.20	68.53	76.70
V ₃ S ₂	115.02	86.12	76.55	69.86	69.06	67.41	75.52
V ₃ S ₃	116.92	87.85	78.21	71.63	70.94	69.37	77.61
V ₃ S ₄	116.81	87.83	78.216	71.76	71.15	69.64	77.91
V ₃ S ₅	119.36	89.96	80.21	73.55	72.88	71.32	79.67
Mean	115.95	87.00	77.40	70.83	70.12	68.54	76.72

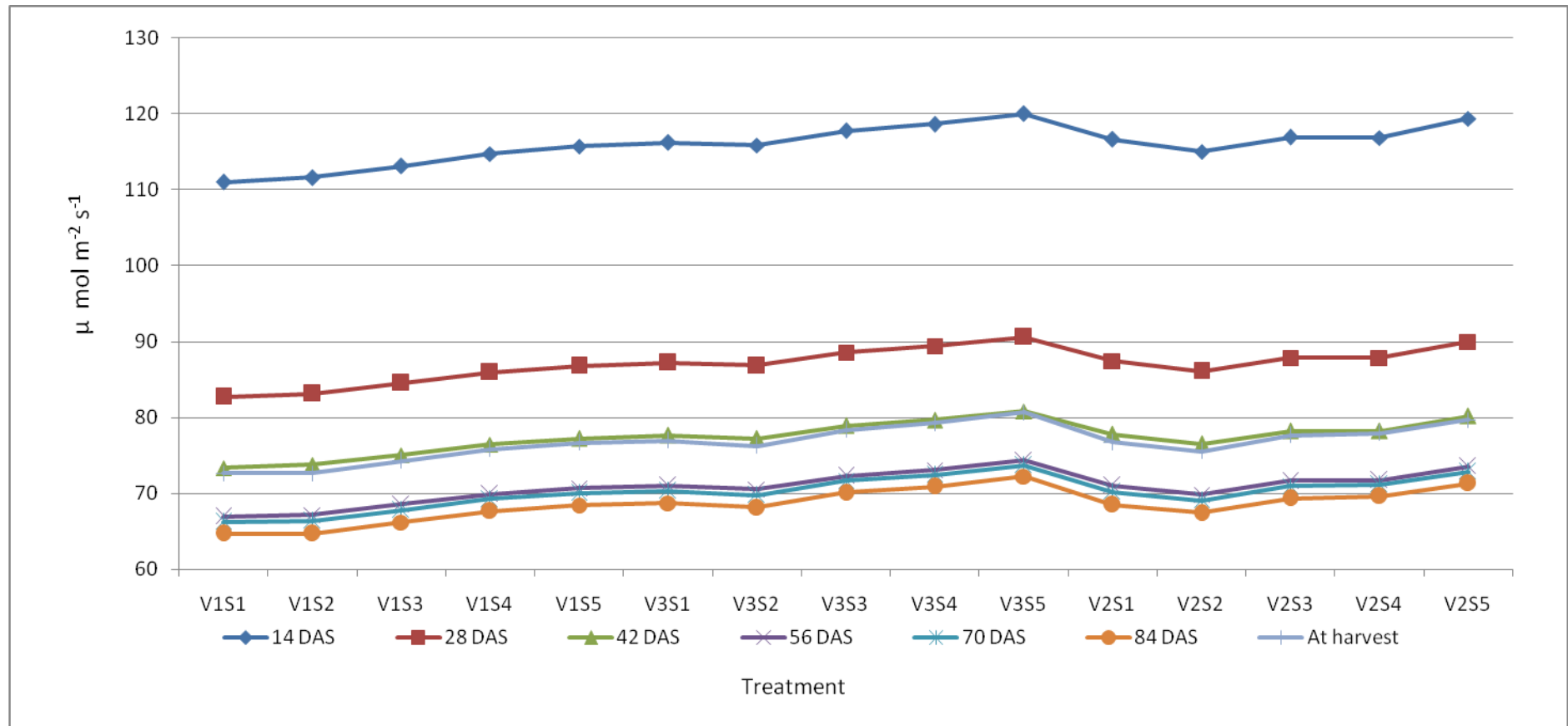


Fig.15. Soil reflected Photosynthetically active radiation (PAR) ($\mu \text{ mol m}^{-2} \text{ s}^{-1}$) by *rabi* linseed as influenced periodically by different treatments

4.5.4.5 Absorbed Photosynthetically active radiation (PAR)

Photosynthetically active radiation of linseed at different growing stages in different treatments was calculated by using quantum sensor reading (Table 32) and depicted in Fig.16.

The absorbed radiation were calculated from the incident radiation canopy reflected radiations, transmitted radiation and soil reflected radiation.

Mean photosynthetically active radiation increased with increase in growth. The mean value of PAR were 408.82, 485.31, 630.63, 727.20, 798.56, 843.34 and 792.77 at 14, 28, 42, 56, 70, 84 and at harvest, respectively.

Among all the treatments, the variety PKVNL-260 sown during 45th MW gave maximum PAR values at 84 DAS ($834.47 \mu \text{mol m}^{-2} \text{s}^{-1}$) and minimum PAR the NL-97 sown during 48th MW ($411.15 \mu \text{mol m}^{-2} \text{s}^{-1}$) at 14 DAS. The absorbed radiation depends upon the intensity of incident radiation and position of plant organs to the incident radiation. the increase in crop canopy to increase in absorbed radiation.

Table 32: Photosynthetically active radiation (PAR) ($\mu \text{ mol m}^{-2} \text{ s}^{-1}$) absorbed by *rabi* linseed as influenced periodically by different treatment

Days After sowing(DAS)							
Treatment	14	28	42	56	70	84	At harvest
V ₁ S ₁	399.98	473.47	614.10	709.53	780.46	825.12	774.88
V ₁ S ₂	405.03	479.79	622.49	718.51	789.70	834.47	784.16
V ₁ S ₃	404.92	480.00	623.13	719.18	790.35	835.09	784.69
V ₁ S ₄	405.92	481.58	625.56	721.78	792.99	837.73	787.22
V ₁ S ₅	407.31	483.49	628.27	724.67	795.95	840.70	790.13
V ₂ S ₁	409.72	486.35	631.91	728.57	799.98	844.80	794.24
V ₂ S ₂	411.59	488.64	634.90	731.77	803.28	848.13	797.56
V ₂ S ₃	411.09	488.35	634.86	731.72	803.19	848.01	797.35
V ₂ S ₄	410.74	488.31	635.23	732.11	803.54	848.32	797.57
V ₂ S ₅	411.15	488.96	636.23	733.17	804.63	849.40	798.61
V ₃ S ₁	413.98	491.84	639.35	736.52	808.15	853.04	802.39
V ₃ S ₂	410.77	487.47	633.18	729.94	801.41	846.26	795.74
V ₃ S ₃	409.86	486.77	632.72	729.43	800.83	845.63	795.01
V ₃ S ₄	406.76	482.96	627.72	724.08	795.32	840.05	789.45
V ₃ S ₅	413.43	491.72	639.79	736.99	808.57	853.40	802.60
Mean	408.82	485.31	630.63	727.20	798.56	843.34	792.77

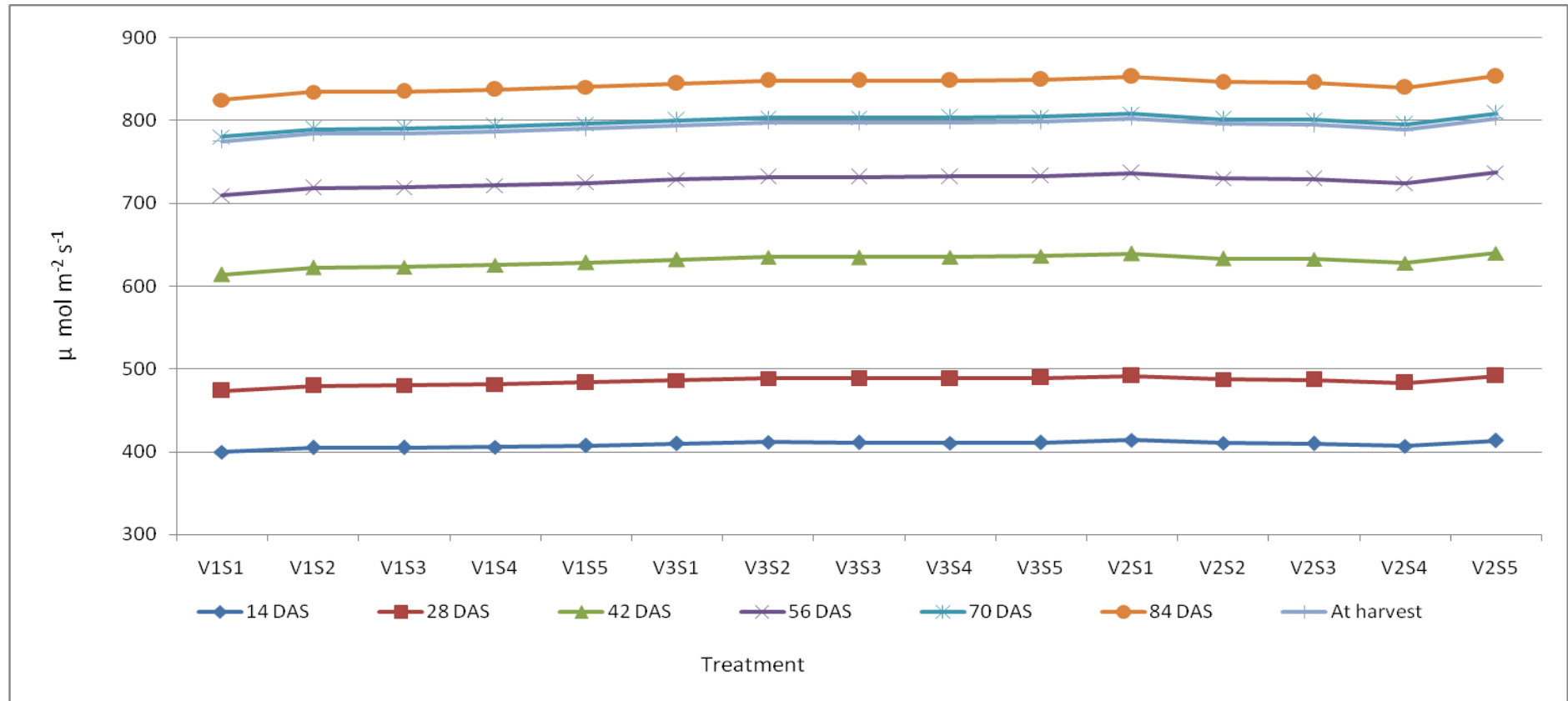


Fig.16. Absorbed Photosynthetically active radiation (PAR) ($\mu \text{ mol m}^{-2} \text{ s}^{-1}$) by *rabi* linseed as influenced periodically by different treatments

4.6 Correlation study:

4.6 Correlation between temperature, humidity with growth and yield contributing characters of linseed varieties

4.6.1 Plant height:

Maximum temperature has been positively correlated with plant height at 28 and 42 DAS . However, it was negatively correlated at 56 and 84 DAS in respect of PKVNL-260 indicating that increase in maximum temperature increased plant height or *vice-versa* (Table 33).

Minimum temperature has been positively correlated with plant height at 28 and 84 DAS. However, it was negative correlated at harvest in respect of PKVNL-260 indicating that increase in minimum temperature increased plant height or *vice-versa* (Table 33).

RH I has been positively correlated with plant height at 56,84 DAS and at harvest. However, it was negatively correlated at 28 DAS in respect of PKVNL-260 indicating that increase in RH I increased plant height or *vice-versa* (Table 33).

RH II has been positively correlated with plant height at 28 and 84 DAS however, it was negatively correlated at 14 DAS and at harvest in respect of PKVNL-260 indicating that increase in RH II increased plant height or *vice-versa*.

Maximum temperature has been positively correlated with plant height at 28 and 42 DAS. However, it was negatively correlated at 56 DAS and at harvest in respect of NL-97 indicating that increase in maximum temperature increased plant height or *vice-versa* (Table 33).

Minimum temperature has been positively correlated with plant height at 28 DAS. However, it was negative correlated at harvest in

respect of NL-297 indicating that increase in minimum temperature increased plant height or *vice-versa* (Table 33).

RH I has been positively correlated with plant height at 56 DAS and at harvest. However, it was negatively correlated at 14,28 and 84 DAS in respect of NL-297 indicating that increase in RH I increased plant height or *vice-versa*.

RH II has been positively correlated with plant height at 28 DAS. However, it was negatively correlated at 14,42 DAS and at harvest in respect of NL-97 indicating that increase in RH II increased plant height or *vice-versa* (Table 33).

Maximum temperature has been positively correlated with plant height at 28, and 42 DAS. However, it was negatively correlated at 56, 84 DAS and at harvest in respect of Padmini indicating that increase in maximum temperature increased plant height or *vice-versa* (Table 33).

Minimum temperature has been positively correlated with plant height at 28 and 84 DAS. However, it was negative correlated at harvest in respect of Padmini indicating that increase in minimum temperature increased plant height or *vice-versa* (Table 33).

RH I has been positively correlated with plant height at 56,70,84 DAS and at harvest. However, it was negatively correlated at 28 DAS in respect of Padmini indicating that increase in RH I increased plant height or *vice-versa*.

RH II has been positively correlated with plant height at 28 and 84 DAS. However, it was negatively correlated at 14 DAS and at harvest in respect of Padmini indicating that increase in RH II increased plant height or *vice-versa* (Table33).

Table 33 : Periodical correlation between temperature , humidity and plant height for different linseed varieties

Parameter	Varieties	14 DAS	28 DAS	42 DAS	56 DAS	70 DAS	84 DAS	At harvest
Tmax	v ₁ -PKVNL-260	-0.011	0.512*	0.790**	-0.778**	0.294	-0.803**	-0.483
	V ₂ -NL-97	0.178	0.616*	0.853**	-0.758**	-0.044	0.126	-0.527*
	V ₃ -Padmini	0.151	0.718**	0.830**	-0.803**	-0.133	-0.746**	-0.505*
Tmin	v ₁ -PKVNL-260	-0.488	0.735**	-0.189	-0.342	-0.479	0.577*	-0.931**
	V ₂ -NL-97	-0.425	0.868**	-0.259	-0.421	-0.132	0.279	-0.944**
	V ₃ -Padmini	-0.413	0.868**	-0.172	-0.395	-0.452	0.521*	-0.869**
RH I	v ₁ -PKVNL-260	-0.456	-0.575*	0.004	0.674**	0.444	0.844**	0.696**
	V ₂ -NL-97	-0.597*	-0.632*	-0.363	0.645*8	0.203	-0.562*	0.733**
	V ₃ -Padmini	-0.435	-0.639*	-0.285	0.658**	0.515*	0.790**	0.617*
RH II	v ₁ -PKVNL-260	-0.612*	0.621*	-0.418	0.102	-0.064	0.860**	-0.822**
	V ₂ -NL-97	-0.638**	0.772**	-0.544*	0.018	0.264	-0.139	-0.801**
	V ₃ -Padmini	-0.536*	0.787**	-0.461	0.060	0.327	0.800**	-0.755**

* Significant at 5%

** Significant at 1%

4.6.2 Number of branches:

Maximum temperature has been positively correlated with No. of branches per plant at 14,28 and 42 DAS however, it was negatively correlated at 56,84 DAS and at harvest in respect of PKVNL-260 indicating that increase in maximum temperature increased Number of branches or *vice-versa* (Table 34).

Minimum temperature has been positively correlated with No. of branches per plant at 28 and 84 DAS. However, it was negative correlated at harvest in respect of PKVNL-260 indicating that increase in minimum temperature increased plant branches or *vice-versa* (Table 34).

RH I has been positively correlated with No. of branches at 56,70,84 DAS and at harvest. However, it was negatively correlated at 14 and 28 DAS in respect of PKVNL-260 indicating that increase in RH I increased branches or *vice-versa* (Table 34).

RH II has been positively correlated with No. of branches at 28 and 84 DAS. However, it was negatively correlated at 14 DAS and at harvest in respect of PKVNL-260 indicating that increase in RH II increased branches or *vice-versa*.

Maximum temperature has been positively correlated with No. of branches per plant at 14 and 28 DAS. However, it was negatively correlated at 56 and 84 DAS in respect of NL-97 indicating that increase in maximum temperature increased branches or *vice-versa* (Table 34).

Minimum temperature has been positively correlated with No. of branches per plant at 28 and 84 DAS. However, it was negative correlated at 56,70 DAS and at harvest in respect of NL-297 indicating that increase in minimum temperature increased branches or *vice-versa* (Table 34).

RH I has been positively correlated with No. of branches at 56,84 DAS and at harvest. However, it was negatively correlated at 14,28 DAS in respect of NL-297 indicating that increase in RH I increased branches or *vice-versa*.

RH II has been positively correlated with No. of branches per plant at 28 and 84 DAS. However, it was negatively correlated at 14 DAS and at harvest in respect of NL-97 indicating that increase in RH II increased branches or *vice-versa*.

Maximum temperature has been positively correlated with No. of branches per plant at 28, and 42 DAS. However, it was negatively correlated at 56,84 DAS and at harvest in respect of Padmini indicating that increase in maximum temperature increased branches or *vice-versa* (Table 34).

Minimum temperature has been positively correlated with No. of branches per plant at 28 and 84 DAS. However, it was negative correlated at 56,70 DAS and at harvest in respect of Padmini indicating that increase in minimum temperature increased branches or *vice-versa* (Table 34).

RH I has been positively correlated with No. of branches per plant at 56,70,84 DAS and at harvest. However, it was negatively correlated at 14, 28 and 42 DAS in respect of Padmini indicating that increase in RH I increased branches or *vice-versa* (Table 34).

RH II has been positively correlated with No. of branches per plant at 28 and 84 DAS. However, it was negatively correlated at 42 DAS and at harvest in respect of Padmini indicating that increase in RH II increased branches or *vice-versa* (Table 34).

Table No. 34: Periodical correlation between temperature , humidity and No. of branches/plant for different linseed varieties

Parameter	Varieties	14 DAS	28 DAS	42 DAS	56 DAS	70 DAS	84 DAS	At harvest
Tmax	V ₁ -PKVNL-260	0.535*	0.595*	0.830**	-0.618**	0.022	-0.791**	-0.532*
	V ₂ -NL-97	0.591*	0.695**	0.330	-0.970**	0.084	-0.713**	-0.415
	V ₃ -Padmini	0.327	0.946**	0.754**	-0.515*	-0.135	-0.923**	-0.614*
T min	V ₁ -PKVNL-260	-0.311	0.832**	-0.168	-0.401	-0.452	0.573*	-0.936**
	V ₂ -NL-97	-0.209	0.813**	-0.181	-0.650**	-0.635**	0.774**	-0.905**
	V ₃ -Padmini	-0.068	0.675**	-0.301	-0.724**	-0.658**	0.799**	-0.980**
RH I	V ₁ -PKVNL-260	-0.595*	-0.555*	-0.063	0.645**	0.592*	0.861**	0.724**
	V ₂ -NL-97	-0.708**	-0.721**	-0.233	0.892**	0.426	0.503*	0.686**
	V ₃ -Padmini	-0.897**	-0.912**	-0.597*	0.837**	0.672**	0.704**	0.884**
RH II	V ₁ -PKVNL-260	-0.565*	0.746**	-0.410	0.064	0.210	0.859**	-0.790**
	V ₂ -NL-97	-0.526*	0.704**	-0.454	-0.281	0.060	0.815**	-0.816**
	V ₃ -Padmini	-0.473	0.579*	-0.596*	-0.384	0.296	0.895**	-0.739**

* Significant at 5%

** Significant at 1%

4.6.3 Plant spread:

Maximum temperature has been positively correlated with plant spread at 28 and 42 DAS. However, it was negatively correlated at 56 and 84 DAS in respect of PKVNL-260 indicating that increase in maximum temperature increased plant spread or *vice-versa* (Table 35).

Minimum temperature has been positively correlated with plant spread at 28 and 84 DAS. However, it was negative correlated at harvest in respect of PKVNL-260 indicating that increase in minimum temperature increased plant spread or *vice-versa* (Table 34).

RH I has been positively correlated with plant spread at 56, 84 DAS and at harvest. However, it was negatively correlated at 14 and 28 DAS in respect of PKVNL-260 indicating that increase in RH I increased plant spread or *vice-versa*.

RH II has been positively correlated with plant spread at 28 and 84 DAS. However, it was negatively correlated at 14 and at harvest in respect of PKVNL-260 indicating that increase in RH II increased plant spread or *vice-versa* (Table 34).

Maximum temperature has been positively correlated with plant spread per plant at 28 and 42 DAS. However, it was negatively correlated at 56 and 84 DAS in respect of NL-97 indicating that increase in maximum temperature increased plant spread or *vice-versa* (Table 34).

Minimum temperature has been positively correlated with plant spread at 28 and 84 DAS. However, it was negative correlated at 56,70 DAS and at harvest in respect of NL-297 indicating that increase in minimum temperature increased plant spread or *vice-versa* (Table 34).

RH I has been positively correlated with plant spread at 56,70,84 DAS and at harvest. However, it was negatively correlated at 14

and 28 DAS in respect of NL-297 indicating that increase in RH I increased plant spread or *vice-versa*.

RH II has been positively correlated with plant spread at 28 and 84 DAS. However, it was negatively correlated at 14 DAS and at harvest in respect of NL-97 indicating that increase in RH II increased plant spread or *vice-versa* (Table 34).

Maximum temperature has been positively correlated with plant spread at 28 and 42 DAS. However, it was negatively correlated at 56,84 DAS and at harvest in respect of Padmini indicating that increase in maximum temperature increased plant spread or *vice-versa* (Table 34).

Minimum temperature has been positively correlated with plant spread at 28 and 84 DAS. However, it was negative correlated at 56,70 DAS and at harvest in respect of Padmini indicating that increase in minimum temperature increased plant spread or *vice-versa* (Table 34).

RH I has been positively correlated with plant spread at 56,70,84 DAS and at harvest. However, it was negatively correlated at 14 and 28 DAS in respect of Padmini indicating that increase in RH I increased plant spread or *vice-versa*.

RH II has been positively correlated with plant spread at 28 and 84 DAS. However, it was negatively correlated at 14,42 DAS and at harvest in respect of Padmini indicating that increase in RH II increased plant spread or *vice-versa*.

Table No. 35 : Periodical correlation between temperature , humidity and plant spread/plant for different linseed varieties.

Parameter	Varieties	14 DAS	28 DAS	42 DAS	56 DAS	70 DAS	84 DAS	At harvest
Tmax	V ₁ -PKVNL-260	0.465	0.736**	0.690**	-0.861**	0.091	-0.605*	-0.444
	V ₂ -NL-97	0.167	0.846**	0.742**	-0.972**	0.077	-0.814**	-0.483
	V ₃ -Padmini	0.415	0.758**	0.849**	-0.678**	-0.011	-0.852**	-0.531*
T min	V ₁ -PKVNL-260	-0.333	0.966**	-0.131	-0.160	-0.687**	0.759**	-0.921**
	V ₂ -NL-97	-0.410	0.931**	-0.090	-0.504*	-0.627*	0.722**	-0.951**
	V ₃ -Padmini	-0.350	0.959**	-0.308	-0.589*	-0.631*	0.810**	-0.946**
RH I	V ₁ -PKVNL-260	-0.650**	-0.685**	-0.420	0.847**	0.497	0.556*	0.683**
	V ₂ -NL-97	-0.671**	-0.672**	-0.416	0.771**	0.544*	0.740**	0.726**
	V ₃ -Padmini	-0.560*	-0.695**	-0.145	0.521*	0.599*	0.598*	0.835**
RH II	V ₁ -PKVNL-260	-0.605*	0.909**	-0.450	0.328	0.055	0.837**	-0.828**
	V ₂ -NL-97	-0.665**	0.887**	-0.409	-0.047	0.105	0.897**	-0.834**
	V ₃ -Padmini	-0.568*	0.897**	-0.552*	-0.184	0.190	0.842**	-0.751**

* Significant at 5%

** Significant at 1%

4.6.4 Plant characters:

Maximum temperature has been negatively correlated with No. of capsules per plant, Weight of capsules per plant, No. of seeds per capsule, weight of seeds per plant and Test weight in respect of PKVNL-260, NL-97 and Padmini indicating that that increase in maximum temperature decrease in plant character or *vice-versa* (Table 36).

Minimum temperature has been negatively correlated with No. of capsules per plant, Weight of capsules per plant, No. of seeds per capsule, weight of seeds per plant and Test weight in respect of PKVNL-260, NL-97 and Padmini indicating that that increase in minimum temperature decrease in plant character or *vice-versa* (Table 36).

RH I and RH II have been positively correlated with No. of capsules per plant, Weight of capsules per plant, No. of seeds per capsule, weight of seeds per plant and Test weight in respect of PKVNL-260, NL-97 and Padmini indicating that that increase in RH I to increase in plant character or *vice-versa* (Table 36).

Table No. 36: Periodically correlation between temperature , humidity and plant characters for different linseed varieties.

Parameter	Varieties	No. of capsules /plant	Wt. of capsules /plant	No. of seeds /capsule	wt. of seeds /plant	Test wt.(g)
Tmax	V ₁ -PKVNL-260	-0.712**	-0.651**	-0.779**	-0.712**	-0.901**
	V ₂ -NL-97	-0.783**	-0.736**	-0.852**	-0.725**	-0.868**
	V ₃ -Padmini	-0.721**	-0.727**	-0.854**	-0.749**	-0.832**
T min	V ₁ -PKVNL-260	-0.304	-0.320	-0.150	-0.197	-0.247
	V ₂ -NL-97	-0.237	-0.251	-0.260	-0.249	-0.132
	V ₃ -Padmini	-0.264	-0.281	-0.275	-0.248	-0.148
RHI	V ₁ -PKVNL-260	0.924**	0.916**	0.882**	0.897**	0.772**
	V ₂ -NL-97	0.911**	0.938**	0.886**	0.900**	0.673**
	V ₃ -Padmini	0.956**	0.962**	0.887**	0.910**	0.739**
RHII	V ₁ -PKVNL-260	0.670**	0.645**	0.755**	0.749**	0.628*
	V ₂ -NL-97	0.681**	0.680**	0.677**	0.708**	0.660**
	V ₃ -Padmini	0.689**	0.682**	0.669**	0.714**	0.697**

* Significant at 5%

** Significant at 1%

4.6.4.1 Days to 50 % flowering:

Maximum temperature has been positively correlated with 50% flowering in respect of PKVNL-260, NL-97 and Padmini indicating that that increase in maximum temperature increase in plant character or *vice-versa* (Table 37).

RH I and RH II have been negatively correlated with 50% flowering in respect of PKVNL-260, NL-97 and Padmini indicating that that increase in RH I to decrease in plant character or *vice-versa* (Table 37).

4.6.4.2 Days of maturity:

Maximum temperature has been positively correlated with days to maturity in respect of NL-97 indicating that that increase in maximum temperature increase in plant character or *vice-versa* (Table 37).

RH I has been positively correlated with days to maturity in respect of PKVNL-260 indicating that that increase in RH I to increase in plant character or *vice-versa* (Table 37). Other are not significant.

4.6.4.3 Yield:

Maximum temperature has been negatively correlated with grain, straw and biological yield in respect of PKVNL-260, NL-97 and Padmini indicating that that increase in maximum temperature decrease in yield or *vice-versa* (Table 37).

Minimum temperature has been not significant .

RH I and RH II have been positively correlated with grain, straw and biological yield in respect of PKVNL-260, NL-97 and Padmini indicating that that increase in RH I to increase in yield or *vice-versa* (Table 37).

4.6.4.4 Plant population:

Maximum temperature has been negatively correlated with initial plant population in respect of NL-97 and negatively correlated with final population in respect of PKVNL-260 indicating that that increase in maximum temperature decrease in population or *vice-versa* (Table 37).

Minimum temperature has been negatively correlated with final plant population in respect of Padmini indicating that that decrease in minimum temperature increase in population or *vice-versa* (Table 37).

RH I and RH II have been positively correlated with initial plant population in respect of PKVNL-260 and positively final plant population indicating that that increase in RH I to increase in yield or *vice-versa* (Table 37).

Table No. 37 : Periodically correlation between temperature , humidity and plant characters and yield contributing characters for different linseed varieties

Parameter	Varieties	Days to 50% flowering	Days to maturity	Grain yield	Straw yield	Biological yield	Initial plant papulation	Final plant papulation
Tmax	V ₁ -PKVNL-260	0.915**	0.222	-0.807**	-0.759**	-0.775**	0.012	-0.926**
	V ₂ -NL-97	0.804**	0.502*	-0.695**	-0.660**	-0.672**	-0.781**	-0.209
	V ₃ -Padmini	0.861**	0.392	-0.697**	-0.758*8	-0.740**	0.214	0.262
Tmin	V ₁ -PKVNL-260	0.384	0.014	-0.255	-0.195	-0.214	-0.374	-0.170
	V ₂ -NL-97	0.195	0.099	-0.290	-0.233	-0.252	-0.439	-0.016
	V ₃ -Padmini	0.025	0.017	-0.277	-0.308	-0.298	-0.425	-0.607*
RHI	V ₁ -PKVNL-260	-0.875**	0.594*	0.838**	0.848**	0.845**	-0.710**	0.691**
	V ₂ -NL-97	-0.814**	0.297	0.947**	0.922**	0.931**	0.264	-0.266
	V ₃ -Padmini	-0.619*	0.419	0.955**	0.926**	0.937**	0.356	0.327
RHII	V ₁ -PKVNL-260	-0.552*	0.461	0.671**	0.727**	0.710**	-0.653**	0.616*
	V ₂ -NL-97	-0.708**	0.281	0.690**	0.726**	0.715**	-0.288	-0.307
	V ₃ -Padmini	-0.658*8	0.324	0.702**	0.671**	0.682**	-0.270	-0.386

• * Significant at 5%

• ** Significant at 1%

5. SUMMARY AND CONCLUSIONS

5.1 Summary

The present investigation entitled “Effect of weather parameters on linseed (*Linum usitatissimum* L.) varieties under extended sowing times” was carried out during *rabi*, 2013-14 at Agricultural Meteorology Department Farm, College of Agriculture, Pune-5.

The field experiment was laid out in a split plot design with three replications. There were fifteen treatment combinations comprising of three varieties (PKVNL-260, NL-97 and Padmini) as main plot treatments and five sowing times (44th, 45th, 46th, 47th and 48th MW) as sub plot treatments. The gross and net plot sizes were 3.00 x 2.4 m² and 2.20 x 1.80 m², respectively. A spacing of 30 cm x 5 cm was adopted by using 3 kg seed ha⁻¹. A recommended dose of fertilizer (50:25:00 kg N, P and K ha⁻¹) was applied uniformly to all the treatments. Nitrogen was supplied through urea, phosphorus through single superphosphate and potash through muriate of potash. 50 per cent nitrogen was applied basally and remaining 50 per cent at 30 days after sowing. The sowing was done by line as per treatments.

Seed treatment with *Azotobactor* and PSB was done at the time of sowing. Light irrigation was given immediately after sowing to ensure good germination and plant stand. Total eight irrigations were given whenever crop was in need. Two hand weedings were given to keep the plots weed free. No any plant protection measure was undertaken. The periodical observations on growth and yield contributing characters were recorded to access the treatment effects. The important findings of investigation are summarized as below.

5.1.1 Effect of varieties

Different varieties of linseed showed a significant influence on growth parameters. Plant height, number of branches plant⁻¹, plant spread, days to 50% flowering, days to maturity and dry matter production were significantly more with the variety PKVNL-260 .

The yield attributing characters viz., number of capsules plant⁻¹, weight of dry capsule plant⁻¹, weight of seed plant⁻¹, and thousand seed weight were favourably influenced in case of PKVNL-260.

The highest seed, straw and biological yields were recorded with the variety PKVNL-260 than other variety.

Maximum temperature has been negatively correlated with grain, straw and biological yield in respect of PKVNL-260, NL-97 and Padmini indicating that that increase in maximum temperature decrease in yield or *vice-versa* (Table 37).

Minimum temperature has been not significant .

RH I and RH II have been positively correlated with grain, straw and biological yield in respect of PKVNL-260, NL-97 and Padmini indicating that that increase in RH I to increase in yield or *vice-versa* (Table 37).

5.1.2 Effect of sowing times

Sowing of linseed during different sowing times significantly influenced growth and yield parameters. A plant height, number of branches plant⁻¹, plant spread, days to 50% flowering, days to maturity and dry matter production were significantly more when linseed was sown during 45th MW.

The yield attributing characters viz., number of capsules plant⁻¹, weight of dry capsule plant⁻¹, weight of seed plant⁻¹, and thousand seed

weight i.e. test weight were favourably influenced when linseed was sown during 45th MW.

The highest grain and straw yields were recorded when linseed sown during 45th MW. Due to increased grain yield, straw yield (kg ha⁻¹) was more under sowing of linseed during 45th MW. When PKVNL-260 variety was sown during 45th MW favoured most of the growth and yield contributing characters.

5.1.3 Effect of interactions

The effect of interaction between varieties and sowing times were significant for plant height at (i.e.14, 28, 42, 70, 84 and at harvest), number of branches at all stages (i.e.14, 28, 42, 56, 70, 84 and at harvest), plant spread at all stages (i.e.14, 28, 42, 56, 70, 84 and at harvest), dry matter at stages (i.e.14, 28, 56, 70, 84 and at harvest), 50% flowering, days to maturity, weight of seeds plant⁻¹, number of capsules plant⁻¹ and test weight. Variety PKVNL-260 when sown during 45th MW favourable influenced most of growth and yield contributing characters and yield.

5.2 Conclusions

1. The cultivar PKVNL-260 was proved to be superior in recording more seed yield as compared to other cultivars, therefore, suggested to adopt PKVNL-260 variety for *rabi* linseed cultivation under Pune conditions.
2. Sowing of *rabi* linseed Cv. PKVNL-260 with second date of sowing 45th MW found advantageous in recording more seed yield.
3. Afternoon Relative humidity was positively correlated, whereas, maximum and minimum temperatures and evening Relative humidity was negatively correlated with plant height, number of branches per plant and plant spread at harvest.

Afternoon and evening Relative humidity was positively positively correlated whereas, maximum temperature was

negatively correlated with number of capsules per plant, Weight of capsules per plant, number of seeds per capsule, weight of seeds per plant, test weight, grain, straw and biological yield.

Correlation between minimum temperature and above different yield contributing characters found to be non-significant.

4. Sowing times 48th MW highest required 2246.9, 29210 and 136989 °C growing degree-days, photo thermal unit and Hydro thermal unit respectively.

The higher canopy development helped in higher PAR absorption which increased up to 84 DAS and there after declined due to senescence of leaves in all the treatment. However, PKVNL-260 sown during 45th MW had highest PAR absorption.

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